The Dissertation Committee for Reshma Babra Naidoo

certifies that this is the approved version of the following dissertation:

Fluid Reasoning, Working Memory and Written Expression of 9 to 14 year old Children

with Attention Deficit/Hyperactivity Disorder

Committee:

Margaret Semrud-Clikeman, Supervisor

Diane P. Bryant

Barbara G. Dodd

Edmund Emmer

Claire Ellen Weinstein

Fluid Reasoning, Working Memory and Written Expression of 9 to 14 year old Children with Attention Deficit/Hyperactivity Disorder

by

Reshma Babra Naidoo, B. Paed., M. Ed., M. A., Ph.D.

Dissertation

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Doctor of Philosophy

The University of Texas at Austin

May, 2007

ACKNOWLEDGEMENTS

This dissertation is the cumulative work of the many individuals who have contributed to in various capacities. First, I would like to express my gratitude to my incredible family for their selflessness, enduring support, and continuing to believe in me even in my moments of deepest despair and angst. This dissertation had been a collaborative family effort. My daughter, Udipta, was always patient and helpful throughout the entire process. Her editing, proofreading, data checking, and secretarial assistance was invaluable for completing this dissertation. She selflessly gave up a chunk of her summer vacation to ensure that this project was completed. My son, Udbhav, whose empathy, sweetness and tenacity has always been a source of inspiration. I am grateful for the many hours that we spent discussing the nuances of the ADHD population that helped refine my thoughts, ideas and hypotheses about the nature of ADHD. His willingness to share his personal experiences allowed me a brief glimpse into challenges that ADHD present. My husband, friend and confidante, Suren, has been an enduring source of encouragement, patience, and faith. His unfailing support of my decision to go back to school, and the grace with which he lived through yet another dissertation is a true testimony of his generosity and depth as a person. My mother, Vidya Ramsingh and my mother-in-law Sheila Naidoo, have led by their example that through support and nurturance we can grow. Their willingness to put their lives on hold so that they could serve as surrogate parents to my children has been inspiring.

My advisor, Margaret Semrud-Clikeman, has been an incredible source of support, inspiration and mentorship. She has helped form and guide both academic and clinical practice. She has always challenged me, forced me to ask the hard questions and search for answers. She sets a high standard I can only hope to aspire towards. Nancy Nussbaum has been a warm and supportive presence, who by her example, guidance and mentorship, has shown me how to use science to guide practice.

I would be remiss not to acknowledge the role of graduate students involved in the NVLD-project who helped secure subjects and test instruments, as well as refine the project. Jenifer Walkowiak, my dissertation partner, was invaluable in data collection, keeping me on track, and keeping the goal in sight. I would like to thank Brianne Butcher for giving up several weekends to help with data collection. Matthew Reynolds was invaluable in helping me understand the sometimes murky world of statistics.

I'd like to thank my dissertation committee, Edmund Emmer and Barbara Dodd for their selfless editing and advising on the statistics; and Claire Ellen Weinstein and Diane Bryant, for their encouragement, support and helpful suggestions. I appreciate the flexibility of my entire dissertation committee for their willingness to convene my dissertation defense on July 3rd, thank you!

Finally, I'd like to thank all the children and their families who participated in this research project, without whom, this study would have been impossible.

Fluid Reasoning, Working Memory and Written Expression of 9 to 14 year old Children with Attention Deficit/Hyperactivity Disorder

Publication No.________________

Reshma Babra Naidoo, Ph. D.
The University of Texas at Austin, 2007

Supervisor: Margaret Semrud-Clikeman

Attention Deficit Hyperactivity Disorder (ADHD) is one of the most prevalent conditions among school children. Executive function deficits representing difficulties in maintaining an appropriate problem set for the attainment of future goals are reported to be the major deficit in ADHD populations. There is a high rate of co-morbidity of learning disabilities and ADHD, with empirical evidence indicating an association with math and reading difficulties, but there is little research on the written expression of this population. There is a body of emergent research indicating that written expression is mediated by executive function. Written expression is a complex task that is affected by motivation, working memory, cognitive processes and long term memory, factors which are reported to be compromised in ADHD populations.

This study evaluated the working memory and fluid reasoning in children with (combined and predominantly inattentive types) and without ADHD. Second, it explored the relationship between working memory and fluid reasoning on written expression in children with and without ADHD. Finally, the possible link between the executive functions of working memory and fluid reasoning, with written expression of children with and without ADHD was examined. The findings of this study indicate that children with the combined type of ADHD had lower written expression and working memory scores compared to children with the inattentive type of ADHD. The results of this study also indicated an association between disinhibition and working memory deficits on written expression performance. This research will serve to contribute to an understanding of the functional impact of ADHD on academic performance. Findings from this study could potentially help with interventions for deficits in written expression among school children.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS iii
Table of Contents v
Glossary of Abbreviations: viii
Glossary of Terms ix
CHAPTER 1 1
Introduction
CHAPTER 2 5
Review of Literature
Attention Deficit Hyperactivity Disorder 6
Executive Functions 16
Written Expression 21
Summary of Research 30
Statement of the Problem 31
Hypotheses 32
CHAPTER 3 35
Method
Participants 35
Power Analysis 38
Measures 39
CHAPTER 4 47
Results
Preliminary Analyses 47
Test of Hypotheses 52
Exploratory Analyses 62
CHAPTER 5 65
Discussion
Summary and Integration of Findings 65
Discussion 67
Limitations 75
Conclusions 81
Directions for Future Research and Clinical Implications 82
APPENDICES 86
Appendix A: Informed Consent to Participate in Research 87
Appendix B: Consent Form 91
Appendix C: Assent Form 92
Reference List 93
VITA 111

LIST OF TABLES

Table 1. DSM –IV TR Diagnostic Criteria for Attention-Deficit / Hyperactivity Disorder, ... 7
Table 2 Analytic Scoring Elements and Criteria for Written Expression........ 44
Table 3 Descriptive Statistics for Total Sample 47
Table 4 Descriptive Statistics for all Variables for Control, ADHD-C, and ADHD-PI Groups 48
Table 5 Sample Distribution by Sex and Race by Diagnostic Status 48
Table 6 The Between Group Effects of Diagnosis on the Dependent Variables 50
Table 7 Tukey Post Hoc Tests for FSIQ-4 by Group 50
Table 8 Correlation Matrix of Dependent and Independent Variables 51
Table 9 Univariate Analysis of Covariance for Written Expression and Written Expression Subtests 53
Table 10 Adjusted and Unadjusted Means for FSIQ-4........ 55
Table 11 Pairwise Comparisons of Group Differences in Adjusted Means of Written Expression........ 56
Table 12 Analysis of Variance Summary Table for Executive Function and ADHD status 58
Table 13 Tukey Post Hoc Comparisons of Group Differences after Controlling for the Effects of FSIQ-4........ 59
Table 14 Adjusted and Unadjusted Group Means for Working Memory and Fluid Reasoning........ 60
Table 15 Regression Model for Variables Predicting Written Expression Performance (N=51)........ 61
Table 16 Analysis of Variance Summary Table for Written Expression with Working Memory and Fluid Reasoning........ 61
Table 17 Summary of Sequential Regression Analysis for Variables Predicting Written Expression (N=51) 62
Table 18 Summary of Linear Regression Analysis for Disinhibition Predicting Working Memory and Written Expression (N=51) 63
Table 19 Regression Model for Variables Predicting Working Memory and Written Expression Performance (N=51)........ 64
Table 20 Analysis of Variance Summary Table for Disinhibition with Working Memory and Written Expression........ 64

TABLE OF FIGURES

Figure 1. Diagram illustrating the hybrid model of executive functions (boxes) and the relationship of these four functions to the behavioral inhibition and motor control systems. 14
Figure 2. Adjusted mean written expression quotients by ADHD group. 57
Figure 3. Comparison of Adjusted mean written expression subscales by ADHD group status 57
Figure 4. Fluid reasoning and working memory by ADHD-Group status 59
Figure 5. Multiple regression analyses for the prediction of written expression from working memory 62

GLOSSARY OF ABBREVIATIONS:

ADHD	Attention-Deficit/Hyperactivity Disorder
ADHD-C	Attention-Deficit/Hyperactivity Disorder, Combined Type
ADHD-PI	Attention-Deficit/Hyperactivity Disorder, Predominantly Inattentive Type
ADHD-H	Attention-Deficit/Hyperactivity Disorder, Predominantly Hyperactive/Impulsive type.
FSIQ-4	Full Scale IQ 4 from the WASI
SAT	Scholastic Achievement Test
TAKS	Texas Academic Knowledge and Skills
EF	Executive Functions
FR	Fluid Reasoning
Gf	Fluid Intelligence
LD	Learning Disabilities
WE	Written Expression
WM	Working Memory
WMC	Working Memory Capacity

GLOSSARY OF TERMS

Attention Deficit Hyperactivity Disorder is a characterized by a persistent pattern of inattention and/or hyperactivity-impulsivity that is more frequently displayed and more severe than is typically observed in individuals at a comparable level of development.

ADHD-C is characterized by the presence of six or more symptoms of inattention and six or more symptoms of hyperactivity/impulsivity that persisted for more than 6 months.

ADHD-H is characterized by the presence of six or more symptoms hyperactivity/impulsivity and fewer than six symptoms of inattention that persisted for more than 6 months.

ADHD-PI is characterized by the presence of six or more symptoms of inattention but fewer than six symptoms of hyperactivity/impulsivity that persisted for more than 6 months.

Conditional Knowledge relates to contexts and circumstances of using specific procedures, addressing "when," "where" and "why" information.

Declarative knowledge is the recalling of information that has been learned. Declarative knowledge is knowledge *about* something.

Fluid reasoning is broadly defined as the ability to reason, form concepts and solve problems that often involve unfamiliar information or procedures, and is manifested in the reorganization, transformation, and extrapolation of information.

FSIQ a composite of measures that provide indices for verbal, perceptual reasoning, processing speed and working memory indices.

FSIQ-4 is a composite of the 4 subtests that measure verbal and performance indices.

Learning disability is operationally defined as an ability-achievement discrepancy in which the achievement score is more than one standard deviation unit below the ability score.

Procedural knowledge is knowing how things work under different sets of circumstances. Procedural knowledge is knowledge of how to do something.

Working memory is the ability to hold a mental representation in mind and use it to guide behavior.

Written Expression is defined as the writing skills that include informal writing skills of note and report writing, and formal writing skills that include letter and passage writing incorporating the elements of grammar, sentence construction and the use of contextual language skills.

CHAPTER 1

Introduction

Attention deficit hyperactivity disorder (ADHD) is the most commonly diagnosed learning difficulty amongst school aged populations. Estimates for prevalence rates of ADHD for school-aged children range from 3% to 7% (Barkley, 2003a). ADHD is characterized by a persistent pattern of inattention and/or impulsivity-hyperactivity that is more severe than is observed in typically developing children of a comparable developmental stage, some of which are present before 7 years of age (American Psychiatric Association, 2000). A wane in hyperactivity symptoms during late adolescence and adulthood is frequently seen in affected individuals. This trend has led to the contention that ADHD is a developmental disorder that is often remediated by catch-up growth occurring across adolescence (Zentall, Moon, Hall, & Grskovic, 2001). Inattention symptoms, on the other hand, have a later trajectory for identification and remain relatively stable over time (Barkley, 2003a).

ADHD is conceptualized as a neurobiological disorder with concomitant executive function deficits that represent difficulties in maintaining an appropriate problem set for the attainment of future goals. Working memory and fluid reasoning, in particular, appear to have the greatest impact on the functioning of ADHD individuals. Anatomic, structural and functional imaging indicate an overlap in the neural control areas for attention/inhibition (Castellanos et al,. 1996; Rubia et al., 1999; Zametkin et al.,

1990) and the executive functions of working memory, attention control, and novel reasoning (Duncan, 1995; Kane, & Engle, 2005; Duncan et al., 2000, Owen, 1997).

Despite the vast body of research on ADHD, there are significant gaps in understanding the cause or mechanisms underlying ADHD, as well as the long-term functional implications of this disorder. ADHD is associated with significant impairment in social and academic adjustment and functioning (Barkley, 2003a; Zentall et al., 2001). Individuals with ADHD have poor long term psychiatric, social, and academic outcomes (Barkley, Fischer, Edelbrock, & Smallish, 1990; Biederman et al., 1996; Hart, Lahey, Loeber, Applegate, & Frick, 1995), and are at greater risk for grade retention (Biederman et al., 2004). Academic deficits are more marked in individuals with the inattentive type of this disorder (Barkley, 2003a), placing them at greater risk for academic failure compared to individuals with the combined or hyperactive/impulsive types of this disorder.

Academic success and learning are largely dependent upon the individual's ability to demonstrate knowledge through the medium of writing. The demands for well produced written expression increases as grade level increases. Furthermore, there has been a recent shift towards increasing accountability for the quality of written expression on high stakes tests such as the TAKS and the SAT. Given that the quality of written expression plays an important role in academic success, understanding the underlying mechanisms that differentiate good writers from poor writers would have significant implications for instruction and intervention.

Written expression relies on many neurobiological components that are compromised in ADHD. There is emergent empirical evidence (e.g., Hooper et al,. 2002; Kellogg, 1999) that supports the theory of written expression as an executive function task (e.g., Hayes and Flower, 1980; 1986). The executive functions of working memory and fluid reasoning, in particular, appear to contribute significantly to written expression. Writing is a problem solving task that is affected by the ability of the individual to mentally manipulate and use information (i.e., working memory) in the reasoning process. The writer is required to switch between the different tasks of writing, goal setting and planning a set of actions (i.e., fluid reasoning). Thus, working memory and/or fluid reasoning deficits are hypothesized to result in impaired written expression.

There is a high rate of co-morbidity of diagnosed learning disabilities and ADHD, with much research supporting an association with math and reading difficulties in ADHD populations. However, written expression is understudied in this population and there is little comparison data. Given the high prevalence of learning difficulties in reading and math in the ADHD population, a similar trend is expected for written expression.

The focus of this study was to examine the possible link between the executive functions of working memory and fluid reasoning, and written expression abilities among children with ADHD predominantly inattentive type (ADHD:PI), ADHD combined type (ADHD:C), and without ADHD. The primary focus of this study was to determine if a there is a qualitative difference in the written expression among children with different ADHD subtype. It was expected that children with the inattentive type of the disorder would have significantly poorer written expression compared to children with the combined type of the disorder. Data from this study revealed that children with ADHD:C performed significantly poorer on tasks of written expression compared to children with ADHD:PI. Secondly, this study examined whether differences in working memory among ADHD subtypes were significant. The working memory of the ADHD-PI group was expected to be significantly lower than that of the ADHD-C group. Results of this study, however, revealed that the ADHD:C sample had a significantly poorer performance on working memory tasks compared to the ADHD:PI group. The final purpose of this study was to determine if differences in written expression could be explained by the executive functions of fluid reasoning and working memory. Working memory was found to be a good predictor of performance on written expression. Data revealed that individuals with higher working memory scores had significantly higher scores on written expression tasks compared to those who had lower working memory scores. This study is one of the first to address the relationship between written expression and executive functions in ADHD populations.

This research contributes to understanding the functional impact of ADHD on academic performance. Findings from this study could potentially be used to assist in the development of interventions and instruction to remediate deficits in written expression among school children. It is hoped that the findings from this study are a significant contribution to understanding the written expression deficits in ADHD populations, stimulating further exploration of the area.

CHAPTER 2

Review of Literature

This integrative analysis and interpretation of scholarly research into the functional implications of executive function deficits in individuals with attention deficit/hyperactivity disorder (ADHD) provides an overview of the neurological and neuropsychological research on ADHD. It specifically focuses on the relationship between fluid reasoning, working memory and written expression. First, since the understanding of the disorder is important, a description of ADHD is provided. This is followed by a review of the neuropsychological underpinnings of ADHD, with particular emphasis on fluid reasoning and working memory. The functional implications of ADHD, fluid reasoning, and working memory deficits will be explored. The impact of executive functions on written expression will be reviewed in this section. The next section focuses on written expression. First, a review of pertinent scholarly literature on the development of written language skills will be reviewed. This will be followed by a review of literature clarifying the executive function-written expression relationship. Then, the relationship between ADHD, fluid reasoning, working memory, and written expression would be explored. Finally, a summary of the research, a statement of the problem, and research questions and their hypotheses will be presented.

Attention Deficit Hyperactivity Disorder

Attention Deficit Disorder is characterized by overt symptoms that include inattention, hyperactivity and impulsivity, or a combination of these two factors and is estimated to affect between 3% to 7% of school-aged children (APA, 2000). Longitudinal studies of ADHD populations have shown that for up to 70% of children who suffer from ADHD, the symptoms of the disorder continue into adolescence and adulthood (Barkley, 1998; Swanson et al., 1998; Taylor, 1998).

What is Attention Deficit Hyperactivity Disorder?

Attention Deficit Hyperactivity Disorder (ADHD) is defined as a developmental disorder characterized by difficulties with sustained attention, distractibility, hyperactivity, and impulse control (Barkley, 2000). ADHD is a syndrome of persistent, disordered behaviors, that when clustered together fall into the categories of predominantly hyperactive, predominantly inattentive or combined types. The DSM-IV criteria for inclusion in these categories are based on the presence of symptoms of inattention, hyperactivity and/or impulsivity outlined in Table 1. Individuals with six or more symptoms of inattention, but fewer than six symptoms of hyperactivity-impulsivity, are classified as the predominantly inattentive type. Individuals who have six or more symptoms of hyperactivity-impulsivity, but fewer than six symptoms of inattention, are classified as the predominantly hyperactive type. Individuals who have six or more of both inattentive and hyperactivity-impulsivity symptoms are classified as having the combined type of the disorder (APA, 2000).

Table 1.
DSM –IV TR Diagnostic Criteria for Attention-Deficit / Hyperactivity Disorder, (From: DSM-IV TR, American Psychological Association, Washington, DC, pp.92-93.)

A. (1) and (2):

1. Six or more of the following symptoms of inattention have persisted for at least 6 months to a degree that is maladaptive and inconsistent with developmental level:
   Inattention:
   a. often fails to give close attention to details or makes careless mistakes in schoolwork, work, or other activities
   b. often had difficulty sustaining attention in tasks or play activities
   c. often does not seem to listen when spoken to directly
   d. often does not follow through on instructions and fails to finish schoolwork, chores, or duties in the workplace (not due to oppositional behavior or failure to understand instructions)
   e. often had difficulty organizing tasks and activities
   f. often avoids, dislikes or is reluctant to engage in tasks that require sustained mental effort (such as schoolwork or homework)
   g. often loses things necessary for tasks or activities (e.g., toys, school assignments, pencils, books or tools)
   h. is often easily distracted by extraneous stimuli
   i. is often forgetful in daily activities
2. six or more of the following symptoms of hyperactivity-impulsivity have persisted for at least 6 months to a degree that is maladaptive and inconsistent with developmental level:
   Hyperactivity
   a. often fidgets with hands or feet or squirms in seat
   b. often leaves seat in classroom or in other situations in which remaining seated is expected
   c. often runs about or climbs excessively in situations in which it is inappropriate (in adolescents or adults, may be limited to subjective feelings of restlessness)
   d. often has difficulty playing or engaging in leisure activities quietly
   e. is often "on the go" or acts as if "driven by a motor"
   f. often talks excessively
   Impulsivity
   a. often blurts out answers before questions have been completed
   b. often has difficulty awaiting turn
   c. often interrupts or intrudes on others (e.g. butts into conversations or games)

B. Some hyperactive-impulsive or inattentive symptoms that caused impairment were present before age 7 years.

C. Some impairment from the symptoms is present in two or more settings (e.g. at school and at home).

ADHD is viewed as a disorder of hyperactivity and attention (Barkley, Du Paul, & McMurray, 1990; Lahey et al., 1994). Deficits in response inhibition, self-control, and impulsivity are some of the consistent findings in ADHD. Impulsivity is considered the core symptom, causative of all other symptoms, that is manifested as motor impulsivity in the hyperactive type, and cognitive impulsivity in the inattentive type (Barkley, 1997a).

Attention

Attention is made up of focused, shift, and sustained attention; encoding capacity; and attentional stability (Mirsky, 1996), and is affected by the internal (physical and emotional) state of the individual. The ability to attend to stimuli is affected by temporal factors related to the presentation of the stimuli, anticipation or the preparation for the response, delay of the response, and motivational factors (Cohen, 1994). Novelty, complexity, and strength influence the attractiveness of the stimulus. It is argued that inattention may actually be evidence of impaired working memory and not of perceptual, filtering, or selection problems (Barkley, 1997b).

The trend towards separating the inattentive (ADHD:PI) from the combined (ADHD:C) and the hyperactive/impulsive (ADHD:H) subtypes of ADHD is based on the thesis that these are two different types of the disorder (Barkley, 1997a, 2003a; Milich, Balentine, & Lynam, 2001). There is also accruing support for the notion that ADHD:PI may in fact represent two distinctly different disorders (Barkley, 1998; Milich et al., 2001). Barkley (2003a) argues that the first subtype of ADHD:PI includes individuals who (i) formerly met the criteria for ADHD:C, but had a sufficient decline in their hyperactive symptoms so that they no longer qualified for this subtype, or (ii) just failed to meet the minimum threshold for hyperactive/impulsive symptoms for the diagnosis of a combined type of this disorder. The second subtype of ADHD:PI is argued to be a subgroup of individuals who have a qualitatively different disorder of attention and cognitive processing (Barkley, 2001; Milich et al. 2001) that is manifest as sluggish cognitive tempo, inconsistent alertness and orientation, passivity, error prone information processing, hyperactivity, lethargy, and a selective attention deficit (Barkley, 1998; McBurnett, Pfiffner, & Frick, 2001) . If two distinct subtypes of ADHD:PI are indeed subsumed under the diagnostic category of ADHD:PI, presenting them under the general rubric of ADHD may in fact belie the functional implications and deficits underlying each subtype. Notwithstanding the possible misclassification of individuals, the DSM-IV criteria for the classification of ADHD:PI will be used in the present study, and as such treated as a single subtype of ADHD.

There is developing consensus that the etiology and expression of ADHD is a combination of genetic and environmental factors. The prevalent clinical diagnosis of ADHD is based on commonly observed characteristics of an inability to sustain attention, and symptoms of hyperactivity and impulsivity (Barkley, 2000). The preponderance of behavioral manifestations of ADHD has led to focusing at the output level of behavior, rather than at the perceptive level. A behavioral approach does not facilitate an understanding of the systemic basis for the disorder and fails to provide a theoretical reference for research purposes.

Impulsiveness

Impulsiveness is an inappropriate, speedy, premature, highly variable, poorly controlled, rapid response style that affects behavioral output (Rubia, 2002). It is pervasive and evenly distributed among the motor, emotional, attentional, cognitive and social domains. All behavior has motor, emotional, cognitive and social acts, and these behaviors are characterized by impulsivity in the individual with ADHD. Characteristics of impulsiveness include a deficit in inhibiting impulses, reduced self-control, a lack of persistence, reduced decision time, increased threshold for boredom, risk taking, sensation seeking, novelty seeking, lack of persistent ambition, resistance to delayed rewards, irritability, and lack of patience (Evenden, 1999).

Hyperactive children tend to show slower reaction times on cognitive tasks (Pennington, & Ozonoff, 1996). They are slower on tasks where speed is requested, and appear to be less able to adjust their own motor responses to the requested speed level (Rubia et al., 1999). However, when they can choose, they choose speed over accuracy (Dykman, Ackerman, & Oglesby, 1979) causing the characteristically fast and premature response style rather than a speed-superiority in absolute terms. This behavior is associated with poor performance on tasks of sustained and controlled attention and interference control (Pennington, & Ozonoff, 1996) on the Stroop and Wisconsin Card Sort Tests.

Theories of ADHD

There is general consensus that ADHD is characterized by problems with inhibitory control (Barkley, 2003a; Fischer et al., 1993a, 1993b; Quay, 1997; Schachar, Tannock, & Logan, 1993; Sonuga-Barke, Houlberg, & Hall, 1994; Sonuga-Barke, Taylor, & Heptinstall, 1992). Individuals with ADHD are, by definition, disinhibited and have slower initiation of inhibitory processes compared to normal children (Barkley, 2003a; Schachar et al., 1993). Several working hypotheses have been generated to explain the diversity observed in ADHD individuals.

The focus on inhibitory systems forms the basis for the first group of models that have been developed to explain the mechanisms underlying ADHD. The Behavior Inhibition/Activation model proposes that ADHD is caused by a central deficit in the brain's behavioral inhibition system (Schachar et al., 1993; Quay, 1997). In this passive avoidance model, response is affected by the conditional stimulus for punishment and nonrewards (Quay, 1997). The inhibitory and activation (reinforcement) processes in ADHD (Fischer, et al., 1993a, 1993b) are hypothesized to trigger both an activation and an inhibitory response to an event or stimulus. This initiation response creates a competition, or race, for the execution of both the activation and inhibitory responses. The impulsive responses of individuals with ADHD are postulated to be due to deficits in the inhibitory system. The aversion to delay, on the other hand, rather than a failure of inhibition, is proposed as the cause of the impulsive behaviors in the Delay Aversion Model (Sonuga-Barke et al., 1992; Sonuga-Barke et al., 1994). Recent developments of this model have included the dual pathway model involving both delay aversion and inhibition.

The second group of theories attempts to account for individual variation by including the associated symptoms that are subsumed under the concepts of motor control and executive function. ADHD is viewed as a state regulation deficit in the Resource Allocation Hypothesis (Sergeant, Oosterlaan, & Van der Meere, 1999; Sergeant & Van der Meere, 1990, 1994). Deficits are in the controlled processes of the disorder, rather than in automatic processing, implying a systemic inability to regulate behavior (Sergeant & Van der Meere, 1990). The slow and variable response time of children with ADHD is hypothesized to be due to a deficit in the regulation of effort and/or activation in the motor response stage of information processing (Sergeant & van der Meere, 1990, 1994; Sergeant et al., 1999). Performance deficiencies may reflect the mismatch between the actual state of the participant and the state required (or target state) for performing a particular task.

In contrast, in the Executive Dysfunction Theory behavioral inhibition is proposed as the primary deficit in the predominantly hyperactive/impulsive and combined types of ADHD (Barkley, 1997a). The assumptions underlying this theory are:

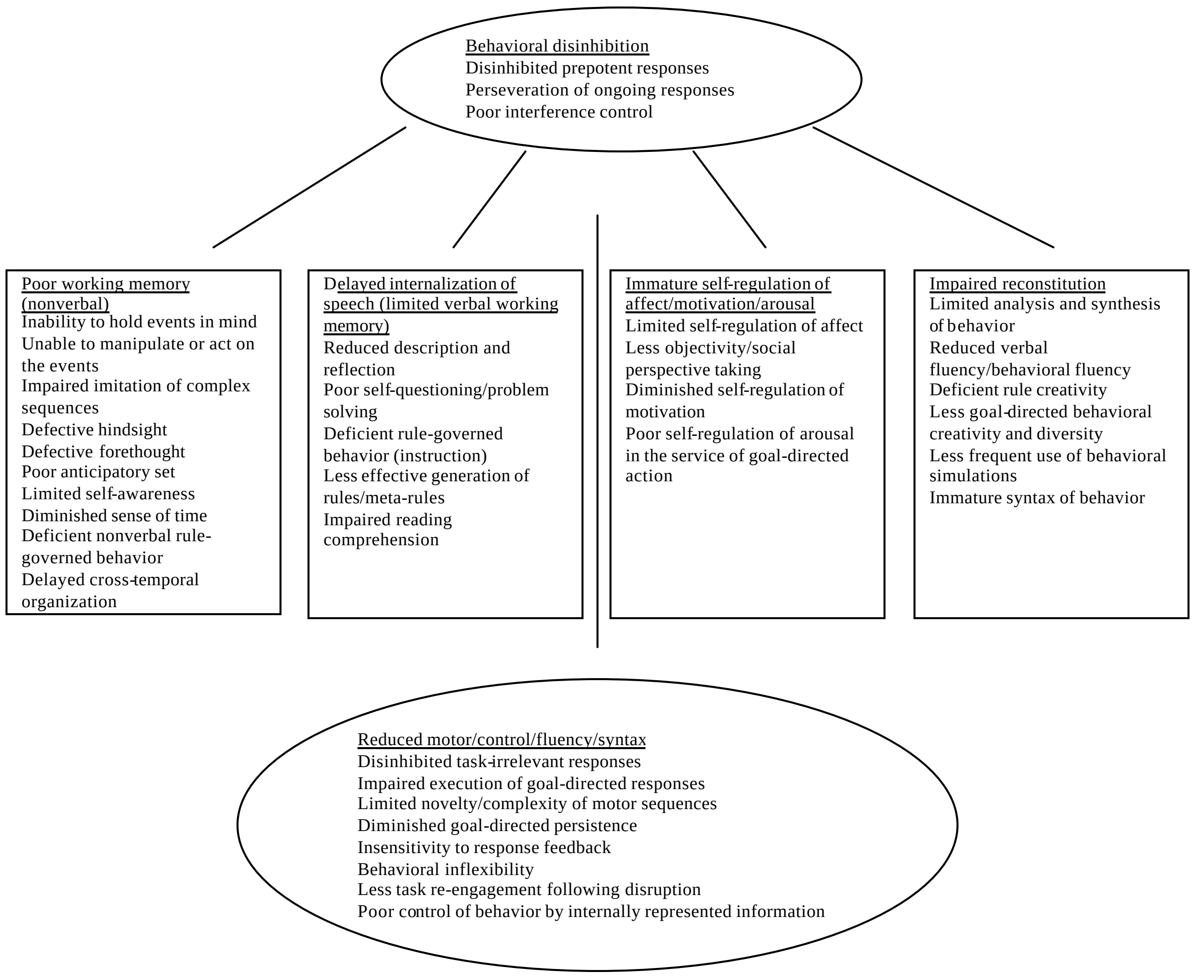
* Executive functions have different developmental rates and trajectories.
* The capacity for behavioral inhibition is a developmental precursor to executive functions.
* Impairment caused by ADHD on executive functions is secondary to behavioral inhibitions.
* Genetics and neurodevelopmental factors are the principal causes of ADHD, but the expression of ADHD is also affected by social factors.
* There is a vicious feedback cycle from secondary deficits in self-regulation that exacerbate the deficits in behavioral inhibition.

The deficit in behavioral inhibition leads to secondary impairments in four executive neuropsychological abilities, namely nonverbal working memory, self-regulation of affect-motivation-arousal, internalization of speech, and reconstitution. These executive functions provide for self-regulation, allowing the individual to tailor a socially appropriate response (Figure 1). The associated executive function deficits observed in ADHD are secondary to the deficit in behavioral inhibition. Barkley (1997a) argues that individuals with ADHD are capable of responding appropriately if they give themselves time to do so.

Neuropsychological Underpinnings of ADHD

The lower IQ scores obtained by children with ADHD, is attributed to an inefficiency in the decision-making and problem solving (Sonuga-Barke et al., 1992) and is associated with their overall functional output. An association between short term memory, fluid reasoning, working memory tasks, and overall scores on cognitive tests has been reported (Kyllonen & Christal, 1990; Duncan, Emslie, Williams, Johnson, & Freer, 1996). Furthermore, performance on novel tasks have a high correlation with measures of general abilities (Ackerman, 2002) and appear to be related to frontal lobe control of executive function and controlled attention (Luria, 1980; Norman & Shallice, 1986).

Figure 1. Diagram illustrating the hybrid model of executive functions (boxes) and the relationship of these four functions to the behavioral inhibition and motor control systems.



From: "Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD" by R. A. Barkley, 1997a, *Psychology Bulletin, 121*(1), pp. 65-94.

Emergent research findings have indicated that the ADHD-IQ association may be due to an overlap in the frontal neurological network areas involved in ADHD (Casey et al., 1997; Castellanos et al., 1996; Filipek, Semrud-Clikeman, Steingard, Kennedy, & Biederman, 1997; Hynd, Semrud-Clikeman, Lorys, Novey, & Eliopulos, 1990), fluid reasoning (Duncan, Burgess, & Emslie, 1995) and intelligence (Engle, Tuholski, Laughlin, & Conway, 1999). The frontal lobe has been implicated in regulating attention, intentional functions, coherence, and assessing behavior across time (Schoenbaum, Chiba, & Gallagher, 1998); modulation of affective and interpersonal behavior to socially appropriate responses (Wood, Romero, Makale, & Grafman, 2003); and monitoring (Blakemore, Wolpert, & Frith, 1998), evaluating and adjusting behavior. The dorsolateral prefrontal circuit is responsible for executive functioning (Daniels, Witt, Wolff, Jansen, & Deuschl, 2003) and includes the ability to organize a behavioral response to solve a complex problem, learn new information, use creativity, or mental flexibility and memory search (Goel & Dolan, 2003), activation of remote memories, self-direction, goal-directed behavior, planning (Koechlin, Basso, Pietrini, Panzer, & Grafman, 1999), maintaining a set, using verbal skills for internal speech necessary to guide behavior, and working memory (Cohen, 1994, Prabhakharan, Smith, Desmond, Glower, & Gabrielli, 1997).

The relationship between genetics, heredity and ADHD lends further support for the organic basis of the disorder. Genetic research (Biederman, Faraone, Keenan, Knee, & Tsuang, 1990; Levy & Hay 2001), and family, twin and adoption studies (Levy, Hay, McStephen, Wood, & Waldman, 1997), indicate a higher than chance clustering of ADHD in first degree families with a 25% incidence compared to 5% in the general population (Biederman et al., 1990). Furthermore, there is a higher concordance rate of ADHD in identical (82 %) than non-identical (38%) twins (Levy et al., 1997).

Executive Functions

Executive functioning is a complex cognitive construct underlying the neuropsychological underpinnings of human cognition. It is defined as “those capacities that enable a person to engage successfully in independent, purposive, self-serving behavior” (Lezak, 1995), and describes “the ability to maintain an appropriate problem set for attainment of future goals" (Welsh & Pennington, 1989, p. 201). Executive functions include components of attention, reasoning, planning, inhibition, set-shifting, interference control, and working memory (Pennington & Ozonoff, 1996). Denckla (1994) proposed the functions of initiating (organization, planning, strategy, fluency, efficiency and working memory), sustaining (attention-driven and attention regulation behaviors), and inhibiting/stopping behaviors (inhibiting and/or delaying inappropriate or prepotent responses), and set shifting (problem-solving efficiency, cognitive flexibility, and self-monitoring) as the four key domains of executive functioning. Numerous theories regarding the relative importance of the different aspects of executive functions have evolved. Working memory is argued to be one of the most important of the executive functions (Tranel, Anderson, & Benton, 1994).

Working Memory.

Working memory (WM) is defined as “the capacity to hold a mental representation in mind to guide behavior” (Baddeley, 1986). Baddeley (1996) proposed that working memory comprises a central executive or attentional controller that recruits two subsidiary systems, namely the phonological loop (private self-speech) and the visuospatial sketchpad (nonverbal working memory), to execute the working memory task (Baddeley & Hitch, 1974; Baddeley & Logie, 1999). For successful activation and execution of a working memory task, the information must be remembered for a period of time after the withdrawal of the cue. The behavioral outcome is a result of a mental manipulation of the cue linked to a conjectured future event.

Working memory reflects the storage requirements and concurrent processing (Baddeley & Logie, 1999). It maintains the system for ongoing cognitive activity such as language comprehension, imagery and reasoning (Kane et al., 2004). Working memory is the ability of the individual to manipulate information and incorporate new experiences to create the unique learning environment. Both response inhibition and cognitive flexibility affect the effectiveness of working memory. Response inhibition provides the initial delay in response to the activation of working memory (Barkley, 2000). Cognitive flexibility (cognitive switching and set-shifting) helps coordinate the ability to look at objects/events from many perspectives, especially when dealing with a novel context (Eslinger & Grattan, 1993).

Individual differences in cognition are argued to arise from processing speed, working memory capacity (WMC), and the breadth of declarative and procedural knowledge (Kyllonen & Christal, 1990; Sut, Oberauer, Wittmann, Wilhelm, & Schulze, 2002). WM requires attention control because the processing component displaces the memory items from attentional focus (Unsworth & Engle, 2005). Individuals with impaired WMC demonstrate less control over thought and actions compared to individuals with superior WMC. They fail to prevent or recover from prepotent responses, showing slower and less flexible allocation of visual attention to objects in space (Kane, Hambrick, & Conway, 2005). WM and fluid intelligence influence the ability to keep a representation active. Controlled attention abilities are proposed as crucial underpinnings of fluid intelligence (Colom, Flores-Mendoza, & Rebollo, 2003; Conway, Cowan, Bunting, Therriault, & Minkoff, 2002; Engle et al., 1999).

Fluid Intelligence.

Fluid intelligence or reasoning abilities are measured in tasks requiring inductive, deductive, conjunctive and disjunctive reasoning to understand relations and abstract prepositions (Horn & Noll, 1997; Stankov, 2000). Fluid intelligence (Gf) is broadly defined as the ability to reason, form concepts and solve problems that often involve unfamiliar information or procedures, and is manifested in the reorganization, transformation, and extrapolation of information. Gf is conceptualized as being ordered along a continuum from elementary awareness to immediate memory to working memory to inductive reasoning to deductive reasoning (Horn & Noll, 1997). It is hypothesized the in order to activate Gf, one must first become aware of stimuli, then hold it in immediate memory and manipulate the stimuli in working memory to inductively perceive the problem. Cognitive speed, attention, concentration and carefulness were also hypothesized to be markers of Gf (Horn & Noll, 1997). Working memory was originally subsumed under Gf within this hypothesis (Horn & Noll, 1997; Kyllonen & Christal, 1990). However, recent research and consensus has been to separate WM from Gf, and view them as separate constructs (Ackerman, Beier, & Boyle, 2002; Colom, Flores-Mendoza, & Rebollo, 2003; Conway et al., 2002; Engle et al., 1999).

Working Memory and Fluid Intelligence.

Does WM represent a distinct cognitive-ability construct that is strongly related to Gf and novel reasoning? Values for the common variance shared between WM and Gf range from 20% (Ackerman, Beier, & Boyle, 2002), to 35 to 65% (Ackerman et al, 2002; Colom, Rebollo, Palacios, Juan-Espinoza, & Kyllonen, 2004; Engle et al., 1999; Sut et al., 2002), indicating that although WM and Gf share common variance, they are separate constructs. The commonality between WM and Gf is that they are both affected by controlled attention (Bachelder & Denny, 1977) and driven by the central executive component (Engle et al., 1999). Neuroanatomical data indicates a dorsolateral prefrontal cortex circuitry involved in working memory, attention control, and novel reasoning (Duncan, 1995; Duncan et al., 2000; Kane & Engle, 2005; Owen, 1997). Gf, however, appears to have a more diffuse neural activation pattern that includes the parietal, temporal and occipital regions (Prabhakharan, Smith, Desmond, Glover, & Gabrieli,. 1997).

Learning Disabilities and ADHD

Individuals with learning difficulties frequently have concomitant deficits in working memory. Empirical research indicates that children and adolescents with undifferentiated ADHD and executive function deficits perform significantly poorer on all academic areas compared to individuals with ADHD individuals without executive function (EF) deficits (Biederman et al., 2004). This EF-academic performance relationship has not been demonstrated in control participants (Biederman et al., 2004). Despite the growing body of research findings that implicate EF deficits in ADHD populations (Seidman, Biederman, Faraone, Weber, & Ouellette, 1997, Seidman, Biederman, Monuteaux, Weber, & Faraone, 2000, Barkley, 1997a), there is a paucity of empirical data on the functional implications of EF deficits of this population. Both anecdotal and empirical data indicate that individuals with ADHD have poor long term psychiatric, social, and academic outcomes (Barkley, Fischer, Edelbrock, & Smallish, 1990; Biederman et al., 1996; Hart, Lahey, Loeber, Applegate, & Frick, 1995), and are at greater risk for grade retention (Biederman et al., 2004).

The majority of clinic referred children with ADHD score below the norms on standardized achievement tests (Barkley, DuPaul, & McMurray, 1990; Hinshaw, 1992, 1994). Reports of comorbid learning disabilities (LD) in children with ADHD range from 25% to 50% (Barkley, 1994). Area specific estimates for learning disabilities comorbid with ADHD in referred samples range from 15% to 50% for reading (August & Garfinkel, 1990; Barkley 1990, Lambert & Sandoval, 1980; Semrud-Clikeman et al., 1992), 24% to 60% for math (Barkley, 1990; Lambert & Sandoval, 1980; Semrud-Clikeman et al., 1992), and 24% to 60% for spelling (Barkley, 1990). Few empirical studies (Hooper et al., 1993, 2002; Mayes, Calhoun, & Crowell, 2000) have investigated the prevalence of learning disabilities in written expression in ADHD populations.

There is some indication that the incidence of a written expression LD in ADHD populations may be higher than is found in the non-ADHD LD population. In a sample of LD subjects (8 to 16 years of age), 69.8% of individuals with ADHD were found to have a comorbid LD in written expression compared to only 39.4% of the non-ADHD LD sample (Mayes et al., 2000). Attention appears to be a major mediator in academic performance and learning disabilities (Mayes et al., 2000). Some researchers have found that children with LD often have subclinical levels of attention difficulties on teacher rating scales (Barkley & Grodzinsky, 1994) that are supported by psychometric measures of attention such as the continuous performance tests (Swanson, 1983; Tarnowski, Prinz, & Nay, 1986). Conversely, other researchers have failed to demonstrate a relationship between learning difficulties and attention measured on continuous performance tests (Aylward, Verhulst, & Bell; 1990; Barkley, Grodzinsky, & DuPaul, 1992). Given the association between attention and written expression (WE), identifying written expression task variables that are susceptible to variations in attention would help elucidate the attention-WE relationships.

Written Expression

There has been an increased emphasis on, and greater accountability for, written expression over recent years. Written expression, or written language skills, have been included on both the Texas Assessment of Knowledge and Skills (TAKS) and Scholastic Aptitude Test (SAT), making it a significant component of high stakes testing. Problems with written expression are common among US schoolchildren. It is estimated that between 20% to 51% of middle school populations in the US have problems with written expression (Hooper et al., 1993; 2002). According to the recent National Assessment of Educational Progress, 16% of students in grades 4 and 8, and 22% of students in grade 12 had below the basic level of writing achievement (Greenwald, Persky, Campbell, & Mazzeo, 1999). An examination of the performance of the 4^{th} grade cohort revealed that only 1% of students were able to write at an advanced level, 23% could write proficiently, and 61% wrote at a basic level. These data indicate that deficits in the written expression are not limited to those with identified LD’s in written expression.

Written expression is affected by a variety of factors that include physical skills (graphomotor dexterity and the mechanics of handwriting), task environment (social and physical) and individual (motivation, working memory, cognitive processes and long term memory) factors. Hayes and Flower (1980; 1986) postulate that written expression output is mediated by executive control processes. Written expression is a socialized, schooled experience and the functional expression of writing is determined by the confluence of these factors.

Development of Written Expression

Written expression, or language-by-hand, is a complex form of communication requiring the mastery and understanding of various complex processing abilities. The ability to write follows a developmental trajectory that is preceded by the abilities to listen, speak and read (Johnson & Myklebust, 1967). Bereiter (1980) identified the following five distinctive characteristics of writing that make it a complex cognitive process. Firstly, written language is more compact, contains more elaborately specified subjects, shows less local variation and has a different distribution of linguistic strategies and usages. Secondly, written and spoken languages are different means of communication with unique structural characteristics. Third, the unique contextual and conventional languages of writing (e.g. spelling, punctuation, and stylistics) are exclusively schooled experiences. Fourth, the lack of feedback during written communication requires the writer to form a discourse that is characterized by explicit reference and logic rather than by a shared experience between the writer and reader. Fifth, writing is a deliberately crafted task using skills that are not normally used in spoken language and can be developed into complex productions. Thus, the development of writing involves (1) the gradual differentiation of written language from spoken language, (2) the ability to switch appropriately between the systems, (3) mastery of the conventions peculiar to written language, (4) explicit, objective, context-free propositional language, and finally, (5) the achievement of literary style and proficiency in various genre of written composition.

Successful writing requires the cognitive and psychological abilities of selective attention, perception, categorization, memory and problem solving. In the production of a written text, the writer simultaneously has to deal with the subject, text and reader (Gregg, 1991). Idea generation and subsequent translation of ideas into written form have to be coordinated. The translation of ideas into written form involves lexical knowledge and retrieval, semantic coding, phonological coding, and syntactic structures (Bain, 1991; Berninger, 1996). Higher order processes that include planning, organizing, self-monitoring, and revising (Graham & Harris, 1999; Hayes & Flower, 1980; Hooper et al., 1993) become more important as the language-by-hand task increases in both length and complexity (Hooper et al., 1993). This facilitates error detection and monitoring the written text for semantic and syntactic expression and coherence, and effective revision and editing. In this dynamic process, information has to be organized, issues analyzed and the written text has to be organized and planned while the writer simultaneously identifies the audience, the purpose of writing, generates information relating to a topic, and engages in sequential ideation relating to a topic. The tasks of written expression are developmental and each phase presents a different challenge. Given the highly integrated and developmental trajectory of producing written text, the failure to gain mastery in formative and foundational areas can impede higher level skills, as well as signal possible difficulties in more complex written expression tasks.

Written text is the integration of several complex cognitive, social and physical skills. The mechanical demands of the task, i.e., the production of script and fine motor skills, also mediate the efficacy with which the individual is able to execute the task. Beginning writers expend considerable cognitive resources on the production of the script that interferes with the higher order processing involved in text composition (Graham & Weintraub, 1996). Attention shifting from planning to handwriting, and the fluency with which the writer is able to jot down thoughts gates the quality of the written text (Graham & Weintraub, 1996). Automaticity in handwriting, on the other hand, allows the individual to concentrate on the more complex aspects of text generation that include ideation, sequencing and monitoring for accuracy (De La Paz & Graham, 2002) that extend beyond the formative writing years (Graham, Berninger, Abbott, Abbott, & Whitaker, 1997) affecting both the quality and quantity of written output (Scardamalia, Bereiter, & Goleman, 1982).

The beginning writer is entrusted with the task of converting the auditory and visual aspects of words into patterns (Johnson & Myklebust, 1967). Handwriting performance is highly correlated with semantics, syntax, phonology (Graham & Weintraub, 1996), linguistic abilities (Abbott & Berninger, 1993; Graham & Weintraub, 1996) and kinesthetic perception (Marcie & Hacaen, 1979; Schneck, 1991). Specialized neural association processes that are dependent on lower and higher brain functioning influence the execution of both graphomotor skills and the production of a written text (Deuel, 1992; Nicolson & Fawcett, 1999). Handwriting affects the rate and level of development of formative writing skills. Impaired compositional fluency in the primary grades has been associated with written composition problems in the upper grades (Berninger, Mizokawa, & Bragg, 1991; Berninger et al., 1997). Learning to automatize letter production and rapidly retrieve letter forms from memory increases the probability that young children would become skilled writers (Berninger et al., 1997). Thus, graphomotor skills and dexterity influence the quality of written expression output.

The lack of automaticity with spelling can inhibit the quality and fluency of written expression. If the writer has to stop and think about how to spell a word while composing, the potential for forgetting already developed ideas increases (Graham et al., 1997). Spelling is the application and integration of phonological (i.e., analyzing the word at the subword level which includes phonemes, rimes or syllables), orthographic (i.e., the retrieval of whole word, letter cluster unit, or a component letter) (Berninger, 1996) and morphological (i.e., whether a word is composed of smaller meaning units) principles (Treiman, 1998). Understanding word meanings also play a role in the spelling of homophones, and increases the fluency of the writer.

Punctuation and language usage are central to a writer's ability to construct meaning at the word, sentence and text levels. Punctuation skills become increasingly sophisticated as writing ability increases. The effective use of punctuation requires cognitive flexibility since it is an "ad hoc language process" in which the rules change each time a new writing structure is built (Weaver, 1998, p.57). Once the writer has mastered the rubrics of writing that include handwriting skills, spelling, vocabulary, and language conventions, the use of complex cognitive and metacognitive skills differentiate good writers from poor writers.

Neuropsychological underpinnings of written expression

Narrative discourse requires a more abstract grasp of language structure than conversation discourse. The concise syntactic style, complexity of sentence structure, rare and rich vocabulary, focus on unfamiliar and abstract topics, and decontextualization or distancing from immediate experiences differentiate written and conversational discourses (Silliman & Wilkinson, 1994). The production of a written text requires the coordination of several highly complex cognitive and metacognitive skills including the generation and organization of ideas, development of a plan, translating the plan into an action, reviewing and revising that which has been written, and monitoring performance during the composition process (Bereiter & Scardamalia, 1987; Flower & Hayes, 1981).

Studies of the qualities of expert writers (Bereiter, 1980; Berninger & Rutberg, 1992; Flower & Hayes, 1981; Hayes & Flower, 1986; Scardamalia & Bereiter, 1986) have revealed that expert writers have a keen knowledge of (i) the goal of the writing task, (ii) the topic, and (iii) their audience. They generate more ideas and produce a more cohesive text with a smooth flow of ideas by using referential, connective and lexical ties for transitions. They make major revisions of their text in order to enhance clarity. They write through a recursive process (i.e., using the generated text towards the generation of the end product), are goal directed, and plan the next sentence or paragraph by translating ideas from the generated text, while constantly evaluating it for its relevance to meeting immediate and future goals (Biederman et al., 2004). Alternately, poor writers show deficits in text generation strategies (Graham, Harris, MacArthur, & Schwartz, 1991), and demonstrate deficits in their acquisition and use of declarative, procedural and conditional knowledge of writing (Biederman et al., 2004), and produce shorter, less interesting, and poorly organized text. They are less likely to revise their contextual or conventional language, or make any substantive changes that would increase the clarity of their communication.

Executive Functions and Written Expression

Written expression is conceptualized as a problem-solving process in which writers attempt to produce visible, understandable, and legible language that demonstrates their declarative, procedural or conditional knowledge (Ellis, 1983; Hayes, 1996; Hayes & Flower, 1980). Declarative knowledge is recalling information that has been learnt, e.g., rules of grammar and its application (Catts & Kamhi, 1999). Procedural knowledge refers to knowledge of how to do something, e.g. the application of grammar rules in communication (Catts & Kamhi, 1999). Conditional knowledge relates to contexts and circumstances of using specific procedures, addressing "when," "where" and "why" information (Catts & Kamhi, 1999).

The neuropsychological functions identified in the writing process are memory, attention, graphomotor output, sequential processing, higher order cognition, language, and visual-spatial functions (Levine et al., 1993). Writing is a complex activity that involves many subgoals and interacting processes (Bereiter, Burtis, & Scardamalia, 1988; Scardamalia & Bereiter, 1986). Recent theoretical discourse on written expression focused on executive functions (Graham, 1997; Hayes & Flower, 1980; Hooper et al., 2002, 2003; Levine et al., 1993; Singer & Bashir, 1999), working memory (Berninger, 1999; Kellogg, 1996, 1999; Lea & Levy, 1999), and the influence of verbal organization and working memory (Abbot & Berninger, 1993; Kellogg, 1999) on the writing process. The executive functions tapping initiation, set shifting, and sustaining are purported to separate the good from the poor writers (Abbot & Berninger, 1993; Hooper et al. 2002; Kellogg, 1999).

Writing is a unique type of problem solving task in that occurs in an environment different from the task environment itself. Scardamalia, Bereiter, and Steinbach (1984) proposed that the planning of writing occurs in two separate yet parallel spaces, the content space (i.e., knowledge states and beliefs) and the problem space (i.e., the rhetorical space tied to production). They argue that there is constant interacting between these two planning environments, but the level of interaction differs for expert and novice writers. Planning is a "preparatory reflection" that may serve to (i) specify the means for, or (ii) serve as the means to achieve the goal (Hayes & Nash, 1996). In addition to determining the means to attaining the goal, planning is also concerned with specifying the goals (Hayes & Nash, 1996). Thus, planning in the writing process is an integral part of the problem solving process, and is dynamic and continually evolves as the text develops.

In addition to planning, recent research suggests that working memory is closely linked with important aspects of written language, such as vocabulary (Dixon, LeFevre, & Twilley, 1988), listening (Daneman & Carpenter, 1980), and reading comprehension (Turner & Engle, 1989). The cognitively demanding processes such as idea generation, translation of ideas into words, sentences and discourse structures, and editing place a great demand on the working memory resources of the writer. Swanson and Berninger (1994) posit that efficiency in writing is affected by working memory capacity. They postulate that good writers are more efficient in consolidating the intermediate steps (i.e., lexical access, syntactic packaging, and construction of discourse structures of translating ideas into written language). This efficiency increases the capacity for higher order processes (i.e., generation, organization, goal setting, planning and revising) of writing.

Working memory, or the cognitive workspace, manages the multifaceted tasks included in written expression. It underlies the active maintenance of multiple ideas, the retrieval of grammatical rules from long-term memory, and the recursive self monitoring that is required during the act of writing (Kellogg, 1996, 1999; McCutchen, 1996; Swanson & Berninger, 1994). A breakdown in working memory, however, may lead to problems with written output (Fayol, 1999; Lea & Levy, 1999).

Kellogg (1996) proposed a working memory based model of writing that includes verbal formulation (planning and translating), execution (programming and executive functions) and monitoring (reading and editing). Each of the major processes of writing is connected by a recursive loop in which the output of the formulation system feeds forward to the monitoring system, and the output of the monitoring system feeds back into both the formulation and execution systems. This recursive loop, derived from Baddeley's (1986) model of working memory, links the visual-spatial sketchpad to formulation, the phonological loop to monitoring, and the central executive to the execution process. Kellogg (1996) postulated that the regulation of ideational fluency, translating ideas into text; correcting errors of organization, grammar and spelling; improving linkages between ideas; and monitoring the overall written product can be influenced by working memory.

There is growing theoretic support for the view that written expression is mediated by executive functions (Abbott & Berninger, 1993; Berninger, 1999; Hayes & Flower, 1980; Flower & Hayes, 1986; Kellogg, 1996; Lea & Levy, 1999). Cognitive flexibility and working memory capacity appear to be key abilities that facilitate the coordination of the dynamic subprocess involved in the creation of written text. However, the relationship between the different facets of executive functioning on written expression is understudied. More empirical research into this area is needed to elucidate the characteristics of good writers, and clarify if these characteristics are indeed deficits in poor writers.

Summary of Research

ADHD is associated with lower academic performance (Barkley, 2003b; Barkley, DuPaul, & McMurray, 1990; Hinshaw, 1992, 1994). Current empirical data indicates that academic difficulties are more prevalent among ADHD:PI compared to ADHD:C individuals (Faraone, Biederman, Mennin, & Russell, 1998; Hynd et al., 1991; Marshall, Hynd, Handwerk, & Hall., 1997; Morgan, Hynd, Riccio, & Hall, 1996). There is an accruing body of research data that indicate that individuals with ADHD have executive function (EF) deficits that result in a poorer academic and learning success (Barkley, 1997a; Pennington & Ozonoff, 1996; Seidman et al., 1997, 2000). However, executive function deficits in the absence of ADHD do not appear to have significant adverse effects on the academic performance of children (Biederman et al., 2004). On the other hand, Hayes and Flower (1980, 1986) postulate that written expression output is mediated by executive control processes. Deficits in written expression have been found in individuals with executive function deficits (Hooper et al., 2002). Given that ADHD is associated with EF deficits, and written expression is mediated by EF processes, individuals with ADHD and comorbid EF deficits are more likely to have poorer written expression compared to individuals without ADHD and comorbid EF deficits.

Statement of the Problem

The purpose of this study was to explore the effects of fluid reasoning and working memory on the written expression of 9 to 14 year old children with the purpose of answering the following: Do working memory and fluid reasoning deficits associated with ADHD compromise the written expression abilities at this developmental stage? Attention Deficit/Hyperactivity Disorder (ADHD) is the most commonly diagnosed learning difficulty among school aged populations (Barkley, 2001). Moreover, there has been increased accountability for the quality of written expression since its reintroduction into high stakes tests such as the Scholastic Achievement Tests (SAT). Thus, an investigation of the effects of ADHD on academic performance helps clarify the educational difficulties confronted by this population.

The confluence of current theoretical thought suggests ADHD as an executive function deficit (Barkley, 1997a; Quay, 1997; Sonuga-Barke et al., 1994), characterized by a difficulty in maintaining the problem set for the attainment of future goals. Working memory and fluid reasoning are implicated in the ability of an individual to maintain the problem set, engage in goal directed behavior, and attain the future goal. An emergent body of research data suggests that executive functioning is a mediator of the successful execution of written expression (Abbot & Berninger, 1993; Hays, 1996; Hays & Flower, 1986; Hooper et al., 2002; Kellogg, 1999). Specifically, the executive functions of fluid reasoning and working memory are postulated to affect goal setting, planning and the attainment of future goals in writing.

Written expression is a multifaceted task that relies on many neurobiological components that are compromised in ADHD. Writing is a problem solving task that is affected by the ability of the individual to mentally manipulate and use information (i.e., working memory) in the reasoning process. The writer has to switch between the different processes of writing, goal setting and planning a set of actions (i.e., fluid reasoning). Since writing is mediated by executive functions, it is hypothesized that executive function deficits would result in impaired written expression.

There is a high rate of co-morbidity of learning disabilities and ADHD (Barkley, DuPaul, & McMurray, 1990), with much research supporting an association with math (Barkley, 1990; Hynd et al., 1996; Semrud-Clikeman et al., 1992) and reading (August & Garfinkel, 1990; Semrud-Clikeman et al., 1992) difficulties in ADHD populations. However, there is little documented data on written expression abilities of individuals with ADHD (Hooper et al., 2002; Mayes et al., 2000). It is hypothesized that written expression performance of ADHD populations would be relatively less developed compared to control subjects.

This study examined the possible link between the executive functions of working memory and fluid reasoning, with the written expression of children with ADHD:PI, ADHD:C, and without ADHD. This research will serve to contribute to understanding the functional impact of ADHD on academic performance. Findings from this study could potentially help with interventions and instruction for deficits in written expression among school children.

Hypotheses

The following research questions and hypotheses were developed to explore the effects of fluid reasoning and working memory capacity on the written expression of 9 to 14 year old children.

Research Question One

Do children with ADHD:PI have more difficulty with tasks of written expression as measured by the written expression subtest of the WIAT-II than children in the ADHD:C and control groups?

Hypothesis One. Children in the ADHD:C Group will demonstrate less difficulty with written expression compared to the children in the ADHD:PI Group, but more difficulty compared to the control group. The control group is expected to perform within the age appropriate norms.

$$H_o\text{: Control > ADHD-C > ADHD-PI}$$

$$H_A\text{: Control = ADHD-C = ADHD-PI.}$$

Research Question Two

Are there significant mean differences in the fluid reasoning (measured on the WJ-III fluid reasoning composite) and working memory capacity (measured on the WISC-IV Working Memory Index) of children in different ADHD groups?

Hypothesis Two. Children with ADHD:PI will have lower fluid reasoning (FR) and working memory capacity (WM) scores than children it the ADHD:C and control groups. Children in the ADHD:C group will demonstrate relatively superior FR and WM scores compared to the children in the ADHD:PI group, but lower FR and WM scores compared to the control group. The control group is expected to perform within the age appropriate expectation.

$$H_o\text{: Control > ADHD-C > ADHD-PI}$$

$$H_A\text{: Control = ADHD-C = ADHD-PI.}$$

Research Question Three

How accurately does fluid reasoning, as measured on the WJ-III, and working memory capacity, as measured on the WISC-IV, predict written expression, as measured on the WIAT-II?

Hypothesis Three. Fluid reasoning and working memory capacity will account for a significant portion of the variance of written expression for all three groups.

CHAPTER 3

Method

Chapter 3 is divided into two major sections: Participants and Instrumentation. The Participants section includes demographic information, criteria used to establish group membership and the data collection procedures. The second section, *Instrumentation*, includes the descriptions and associated psychometric properties of the independent measurement instruments used for group selection.

Participants

Participants for the study were drawn from a larger study examining social competence and developmental disorders that was in progress at the University of Texas at Austin under the direction of Dr. Margaret Semrud-Clikeman. Approval by the Human Subjects Committee was obtained. This study adhered to the ethical issues and standards of research presented by the American Psychological Association and the University of Texas at Austin. A research proposal and appropriate materials was submitted to the Department Review Committee within the Department of Educational Psychology and the Institutional Review Board of the University of Texas at Austin (Appendices A to D). Researchers involved in this project completed the training required by the Institutional Review Board, certifying them to perform ethical research.

Recruitment of Participants.

A recruitment letter (see Appendix A) was sent to schools in the greater Austin area, inviting both clinical and control subjects to participate in the study. The letter described the study and invited students to participate. The letter also explained that the student's choice to participate, or not, would in no way influence or compromise his or her relationship with the University of Texas at Austin. Interested parents contacted the primary researcher by either submitting a note of interest, by email, or telephonically. At the time of initial contact, basic descriptive information such as gender, age, and grade were gathered, a brief interview determining participant eligibility for the study was conducted, and an appointment for testing was set. Both parental consent (Appendix B) and participant assent (Appendix C) was obtained.

Participants

Participants were divided into 3 groups: ADHD:PI, ADHD:C, and healthy controls. The files of existing participants were screened for a relevant diagnosis of ADHD:PI and ADHD:C. Previous diagnoses of ADHD were independently confirmed by the researcher and her advisor. Children from the ages of 9 to 14, with a mean age of 11 years and 7 months were included in the sample. Groups were age and gender matched. Complete data for seventeen participants in each of the two clinical categories (Groups One and Two), and 17 normal controls (Group Three), were obtained. Six subjects were excluded from the sample because of incomplete data. A further 22 participants were excluded from the study because they did not meet the diagnostic criteria for ADHD on one of the classification measures (SIDAC or BASC scores).

This study was limited to right-handed children with no history of brain injury, mental retardation, learning disability, and/or the presence of severe psychopathology requiring pharmaceutical intervention. Subjects in the control group had no history of attention deficit hyperactivity disorder. English was the primary language for participants in all 3 groups.

Participants for the clinical ADHD groups met the diagnostic criteria for ADHD (see Table 1) based on the hyperactivity and inattention scales of parent rated Behavioral Assessment Scales for Children (BASC, Reynolds & Kamphaus, 2002) that were corroborated through structured parent interviews using the Structured Interview for Diagnostic Assessment of Children for DSM-IV (SIDAC, Hynd, Lorys, et al., 1991). Individuals were diagnosed with the combined type of ADHD if at least 6 hyperactive/impulsive and 6 inattention symptoms were endorsed on the ADHD scale and BASC scores were clinically significant for both hyperactivity and attention. Threshold scores for ADHD-C on the BASC were 60 or greater on both the hyperactivity and attention scales, with one of the scores being 65 or greater. Individuals were diagnosed with the predominantly inattentive type of ADHD based on the presence of six or more symptoms of inattention, but fewer than five symptoms of hyperactivity/ impulsivity on the SIDAC, with a threshold score of 65 or greater for attention problems and less than 60 on the hyperactivity scales.

Participants in the control group did not meet the diagnostic criteria for ADHD based on the hyperactivity and attention problems scales on the BASC and the ADHD scale of the SIDAC. They had 5 or fewer endorsements of attention or hyperactivity problems on the ADHD scale of the SIDAC and scores lower than 60 on the both the hyperactivity and inattention scales of the parent rated BASC.

Data Collection

Data collection took place at either the Sanchez building at the University of Texas at Austin, or at the school that the student attended. Once the appropriate consent (see Appendix B) and Assent forms (Appendix C) were collected, the primary researcher and trained graduate students administered the battery of tests for this study. Tests were individually administered to participants. The full battery of tests took approximately 3.5 hours to complete. Past testing was utilized if it was two years current. Thus, for subjects who had completed in the full battery of tests in the past, the time requirement for testing was substantially lower and ranged from 15 minutes for a single subtest to 2 hours for participants requiring a complete retest of all measures needed for this study.

Power Analysis

A power analysis (Cohen, 1992) was conducted using the parameters of alpha = .05 to determine the appropriate number of participants per group. A study conducted by Hooper et al., (2002) was used as a basis for choosing the effect size. In a study of the relationship between the executive functions of initiation and set shifting domains with written expression, when reading decoding was controlled, the effect sizes were small, .16 and .13 respectively, for a sample of 55 fourth and fifth grade children (Hooper et al., 2002). The calculated effect size found on a study of the effects of written expression, learning disabilities and ADHD was very small, effect size = .0194 (Mayes, Calhoun, & Crowell, 2000). A power analysis using data determined that 17 participants per cell (n=51) would be sufficient to yield power of *d* = .58 for ANOVA and *d* = .59 for regression analyses. The observed power for the pairwise comparisons for group differences in written expression were large, ranging from *d* = .732 for differences between ADHD-C and ADHD-PI for overall written expression, to *d* = 1.330 for differences in organization and planning between ADHD-C and the control group, suggesting that both sample size and distribution were adequate to detect significant differences. The ANOVA for group differences on working memory capacity had a large effect size with observed power of d=1.821, indicating that the sample size was adequate and supported statistically significant group differences. These effect sizes were unexpectedly large, given the smaller effect size seen in other studies.

Measures

Behavior Assessment System for Children (BASC)

The Behavioral Assessment System for Children, parent version (BASC, Reynolds & Kamphaus, 2002) is a parent-report behavior rating scale that assesses externalizing and internalizing behaviors in children 4-18 years of age. Behavior descriptors are rated as either never, sometimes, often or almost always. Although parents completed all scales on the measures, only the hyperactivity and attention problem scales of the parent versions of the BASC were used to diagnose ADHD.

The parent version of the BASC has preschool (4 to 5 years of age), children (6-11 years of age) and adolescent (12-18 years of age) forms. Six month test-retest reliability based on the general norms is reported below. The test-retest reliability on the parent rating form ranges from .41 for atypicality to .71 for adaptive skills. Inter rater reliability between parents is .68. Parent ratings on the attention and hyperactivity scales for ages 12 to 14 years had a test-retest reliability of.78 and .77, respectively. The test-retest reliability of the overall BASC for the parent version is .70. Validity for the BASC was assessed through factor analysis, covariance structure analysis and correlation with other instruments. Vaughn, Riccio, Hynd and Hall (1997) found that the BASC was significantly correlated with the DSM-IV diagnostic criteria for different ADHD subtypes.

Structured Interview for Diagnostic Assessment of Children (SIDAC) for DSM-IV

The Structured Interview for Diagnostic Assessment of Children (SIDAC) is a modified and updated version of the K-SADS (Puig-Antich & Chambers, 1978; Puig-Antich & Ryan, 1986) to include the DSM-IV symptoms/disorders (Hynd et al., 1991). The SIDAC was used to support the diagnosis of ADHD by identifying DSM-IV criteria. There are 18 questions, 9 regarding inattention, 6 regarding hyperactivity and 3 regarding impulsivity. Questions related to the DSM-IV exclusionary criteria for ADHD are also included. The K-SADS has a test-retest diagnostic reliability for ADHD to be kappa = .63 (Kaufman et al., 1997). The concurrent validity of the K-SADS, for children who also met the diagnostic criteria for ADHD on the Conners Child Behavior Checklist (CBCL) was found to be higher than that of children who did not meet these criteria on the CBCL ($t = 3.43, p<0.001$) (Kaufman et al., 1997).

Wechsler Abbreviated Scale of Intelligence (WASI)

The Wechsler Abbreviated Scale of Intelligence (Psychological Corporation, 1999) is an individually administered intelligence test for people aged 6 to 89 years. The

Full Scale Intelligence Quotient-4 (FSIQ-4) is a valid and reliable estimate of global ability, and utilizes the four subtests (Vocabulary, Block Design, Similarities and Matrix Reasoning) that have the highest factor loadings on g (Psychological Corporation, 1999). The FSIQ-4, is highly reliable at ages 6 to 16 years, and is highly correlated (.96) with the WISC-III FSIQ. Unlike the FSIQ, the FSIQ-4 comprises verbal and performance indices but does not include working memory capacity and processing speed indices.

The Vocabulary subtest is a set of 42 items. Items 1-4 are visually presented picture items. The participant names the item in the picture. Items 5 to 42 are presented both orally and visually, and the participant orally defines the presented word. The Vocabulary subtest is a measure of expressive vocabulary, verbal knowledge and fund of information. It is good measure of crystallized intelligence. The Similarities subtest comprises of 26 items. Items 1-4 are picture items on which the participant is required to identify the one of four picture choices that goes best with the given set of pictures. Items 5 to 26 are verbal items in which the subject is required to explain the similarity between the pair of words presented. The Similarities subtest is a good measure of abstract verbal reasoning, general intelligence and verbal concept formation. The Block Design subtest is a set of 13 modeled or printed two dimensional geometric patterns that subjects reconstruct using a designated number of two color cubes. The Block Design subtest is a good measure of abilities related to spatial visualization, visual-motor coordination, and abstract conceptualization. It measures perceptual organization and general intelligence. The Matrix Reasoning subtest consists of 35 incomplete grid patterns. The participant chooses one of the five possible choices. It is a measure of nonverbal fluid reasoning and measures general intellectual ability. The split-half reliability coefficients for the subtests are: .86 to .93 for the Vocabulary; .81 to .91 for the Similarities; .84 to .93 for the Block Design; and .86 to .96 for the Matrix Reasoning subtests. The average split-half reliability for PIQ is .93, .94 for the VIQ, and .96 for the FSIQ-4 for children.

Wechsler Individual Achievement Test- Second Edition (WIAT-II) (Wechsler, 1992)

The Wechsler Individual Achievement Test – Second Edition (WIAT-II, Psychological Corporation, 1992) is a comprehensive, individually-administered achievement battery that is designed to be used with students in grades K to 12 who are between 5 to 19 years of age. The WIAT-II was designed to be specific to the educational curriculum and instructional objectives. The WIAT-II parallels areas in which a child can be classified as learning disabled (LD) and provides a link to ability measures. Specifically, it has been standardized with the WISC-III to investigate ability-achievement discrepancies required for LD classification. Reading and writing achievement will be assessed through the administration of 2 subtests: Basic Reading and Written Expression. Parallel to the WISC-III, average standard scores on the WIAT-II fall in the range from 85 to 115. Reliability reports indicate high internal consistency coefficients, from .88 or higher, and moderately high test-retest reliability in the .80 to .95 range (Wechsler, 1992). Additionally, there is adequate evidence for content, construct, and criterion related validity for the WIAT-II subtests and composite scores. Learning Disabilities in the broad areas of Reading will be ruled out using the WIAT-II Reading scales, using cutoff scores that lie within one standard deviation of IQ. The WIAT-II Reading composite has a reported split-half reliability coefficient of .98 and correlates with the Wide Range Achievement Test-Third Edition (WRAT-3) Reading Composite at .77.

Written Expression. The written expression subtest of the WIAT-II was used to measure students' writing skills. The written expression subtest is a composite of a verbal recall task, combining sentences to create complex and compound sentences, sentence generation in response to stimuli, and a passage writing task in response to a prompt. Students receive the prompt and are directed to write a story (grades 3 to 6) or persuasive argument (grades 7 to 12). Students are allowed up to 10 minutes to write the story (grades 3 to 6) or 15 minutes to write the persuasive argument (grades 7 to 12).

All writing samples from the WIAT-II were also subject to an analytic assessment that focused on the parts or elements of written discourse (Table 2). Part assessment of the writing samples included the following 6 writing elements: ideas and development; organization, unity, and coherence; vocabulary; sentence structure and variety; grammar and usage; and capitalization and punctuation using the scoring criteria provided in the WAIT scoring manual (WIAT, 1992, Psychological Corporation). Each element is awarded a score ranging from one (poor) to four (strong. The WIAT-II Writing Composite has a reported split-half reliability coefficient of .89 and correlates with the Wide Range Achievement Test-Third Edition (WRAT3).

Woodcock Johnson Tests of Cognitive Ability

The Woodcock Johnson III Tests of Cognitive Abilities (WJ III Cog) comprises twenty tests that may be given in a variety of combinations and orders. Fluid reasoning was assessed using the Novel/Fluid Reasoning composite attained from the Concept Formation and Analysis Synthesis subtests. The fluid reasoning composite is a measure of inductive and deductive reasoning, problem solving and concept formation on novel

Table 2
Analytic Scoring Elements and Criteria for Written Expression

Ideas and Development

4 points	Extensive development of idea/s, with extension and elaboration on all or most of the points. Look for uniqueness, interest to audience, and strong support of the main idea. Can be exceptional writing or extremely thorough.
3 points	Good development of idea(s), with many details elaborated and extended. Ideas are fairly well supported.
2 points:	Adequately supported idea/s, with some details extended or elaborated. May be an extensive list.
1 point	Weak idea/s minimally supported, with little or no extension of details, or incoherent.

Organization, Unity and Coherence

4 points	Completely organized, with smooth flow from one idea to the next through the use of transitions and sequencing. Unity is strongly evident, with no wandering from the primary theme or plan
3 points	Fairly well organized, with good unity of plan. Some transitions may be used. Little or no digression from main idea.
2 points:	Small amount of organization. Weak plan that may not be well unified. Ideas may be only minimally connected.
1 point	Lack of plan. May be incoherent.

Vocabulary

4 points	Precise, appropriate, accurate, and specific word choices that convey the correct meaning and appeal to the audience. May be vivid and imaginative.
3 points	Good word choices that are appropriate, specific, and varied and have some appeal. May lack “sparkle” but meaning is clear.
2 points:	Fair use of words. May be specific and have a little variety but is very elemental. May be simplistic but effective.
1 point	Very simplistic. Lacks variety and precision. Meaning maybe unclear. May be inappropriate.

Sentence Structure and Variety

4 points	Excellent control and formation of sentences. Variety of sentence structures and sentence lengths contribute to fluency. Few if any errors in structure.
3 points	Adequate amount of sentence variety. Good mix of sentence lengths and structures. May contain a small number of errors that do not interfere with fluency. Error-free papers with no variety.
2 points:	Sentences constructed fairly well. May have some variety in length and structure or may be somewhat monotonous or choppy. May contain several errors and lack control.
1 point	Poor sentence structure with many errors that may inhibit fluency or clarity.

Grammar and Usage

4 points	Error free or very few errors, in approximate proportion to length of the paper.
3 points	Good grammar and word usage. Errors that do not detract from the overall quality of the paper.
2 points:	Fair grammar and word usage. Errors may interfere with meaning.
1 point	Poor grammar and word usage, with frequent or serious errors.

Capitalization and Punctuation

4 points	Error free or very few errors in punctuation and capitalization, in approximate proportions to the length of the paper.
3 points	Most punctuation and capitalization done correctly. Errors do not interfere with clarity.
2 points:	Some errors in capitalization and punctuation; no serious interference with communication.
1 point	Frequent and/or serious capitalization and punctuation errors that may interfere with communication.

tasks that are nonverbal or limited in language demands. The Fluid Reasoning composite has a retest-reliability of .95.

The Concept Formation subtest is a measure of categorical reasoning based on principles of formal logic, and is a strong measure of induction or fluid intelligence. The participant is required to identify the rules when shown illustrations of instances and non-instances of concepts. Feedback regarding the correctness of each response is given. Execution of this task requires concentration, reflectivity versus impulsivity, flexibility versus inflexibility, planning, and the ability to use feedback to modify performance. The Concept Formation subtest has a mean split half reliability of 0.94. The Analysis-Synthesis subtest is a controlled learning task in which the individual is given instructions on how to perform an increasingly complex procedure. The participant is required to solve logical puzzles involving color codes similar to mathematical and scientific symbolic rules. The ability to start with rules, premises or conditions and engage in one or more steps to reach a solution to a problem are required to solve puzzles. Feedback regarding the correctness of the response is given. The Analysis-Synthesis subtest has a split half reliability of 0.90.

<u>Wechsler Intelligence Scales for Children, Fourth Edition (WISC-IV, Wechsler, 2003)</u>

Working Memory Capacity will be assessed using the Working Memory Index (WMI) of the WISC-IV. The WMI is a measure of the ability to hold information in mind temporarily, perform some operation or manipulation with it and correctly produce a result. The WMI is essential for higher order cognitive functioning and is closely related to achievement and learning. It has an average split half reliability of .92 and a test-retest reliability of .85. WMI is a composite of the Digit Span and Letter-Number Sequencing subtests. The Digit Span subtest comprises the Digits Forwards and Digits Backwards tasks. The Digit Forwards and Digit Backwards tasks each comprise of two trials and 8 items. The participant is required to orally reproduce a string of numbers that are dictated by the examiner. The participant is asked to repeat the string of numbers as dictated on the Digits Forwards subtest. On the Digits Backwards task, the subject is asked to mentally manipulate the numbers and repeat them in reverse order to the dictation. The split half reliability for digit span is .87 and .90 for letter-number sequence.

The Letter-Number Sequencing subtest consists of ten items of three trials each. The participant is read a sequence of numbers and letters and is asked to recall the numbers in ascending order and then the letters in alphabetical order. The split half reliability for the Letter-Number-Sequence subtest is .90. Both the Digit Span and Letter-Number-Sequencing subtests are measures of working memory capacity, or the ability to hold information in mind temporarily, to perform some operation or manipulation with the information, and produce a correct result. Working memory capacity is an essential component of fluid reasoning and other higher order cognitive processes and is closely related to achievement and learning.

CHAPTER 4

Results

Preliminary Analyses

Demographics and Group Mean Differences

Demographic information for the total sample (N=51) is presented in Tables 3 and 4. Approximately 65% of the sample were male and 35% female (Table 5). The racial composition of the sample was 72.5% white (n=37), 11.76% Hispanic (n=6), 5.9% (n=3) African American, 1.9% (n=1) Indian, 1.9% (n=1) Asian, and 5.9% (n=3) classified as Other.

Table 3
Descriptive Statistics for Total Sample

	N	Mean	SD	Range
Age	51	11.62	1.72	(9 to 14.92)
FSIQ-4	51	111.90	12.12	(87 to 142)
Fluid reasoning	51	111.02	14.36	(80 to 150)
Working memory	51	99.10	12.69	(74 to 129)
Written expression	51	100.20	14.27	(70 to 131)
Ideas and development	51	2.31	.74	(1 to 4)
Organization, unity and coherence	51	2.45	.73	(1 to 4)
Vocabulary	51	2.33	.68	(1 to 4)
Sentence structure and variety	51	2.14	.69	(1 to 3)
Grammar and usage	51	2.06	.65	(1 to 4)
Capitalization and punctuation	51	2.12	.82	(1 to 4)

Table 4
Descriptive Statistics for all Variables for Control, ADHD-C, and ADHD-PI Groups

	Control	ADHD-C	ADHD-PI
	Mean (SD)	Mean (SD)	Mean (SD)
Grade	5.94 (1.85)	5.12 (1.87)	5.82 (1.67)
Age*	11.65 (1.64)	11.21 (1.77)	12.01 (1.76)
FSIQ	118.06 (11.52)	107.41 (12.98)	110.24 (.67)
Fluid reasoning	115.82 (14.94)	108.41 (13.00)	108.82 (14.67)
Working memory	105.82 (9.06)	89.76 (8.57)	101.71 (14.15)
Written Expression	108.35 (11.92)	90.94 (12.78)	101.29 (12.96)
Ideas	2.82 (.53)	1.82 (.64)	2.29 (.69)
Organization	2.94 (.56)	2.00 (.61)	2.41 (.71)
Vocabulary	2.71 (.59)	1.94 (.66)	2.35 (.61)
Sentence structure	2.65 (.61)	1.71 (.59)	2.06 (.56)
Grammar	2.47 (.62)	1.65 (.49)	2.06 (.56)
Punctuation	2.35 (.79)	1.65 (.61)	2.35 (.86)

* Age in years.

Table 5
Sample Distribution by Sex and Race by Diagnostic Status

	Control	ADHD-C	ADHD-PI	Total Sample
Gender				
Boys	8 (47%)	15 (88%)	10 (59%)	33 (65%)
Girls	9 (53%)	2 (12%)	7 (41%)	18 (35%)
Race				
White	12	14	11	36 (70%)
Hispanic	1	3	2	6
African American	3	0	0	3
Asian Indian	0	0	1	1
Asian, Other	1	0	0	1
Other	0	0	3	3

Participants in this study ranged in age from 9 years and 0 months to 14 years and 11 months with the mean age of 11 years and 7 months (SD = 20 months). FSIQ-4 scores ranged from 87 to 142, with a mean FSIQ-4 of 111.9 (SD=12.12). Participants had a mean education of 5th grade 7 months with a range from the 3rd to 9th grades. As age, IQ and grade can contribute to differences in written expression, one-way ANOVAs were used to test for mean differences between the control, ADHD-C, and ADHD-PI groups on these variables (Table 4). As shown in Table 6, statistically significant differences were not found between the ADHD-C, ADHD-PI and control groups based on age; $F_{(2, 49)} = 0.915$, $p = 0.407$; or grade, $F_{(2, 49)} = 1.042$, $p=0.360$. Statistically significant differences were found for FSIQ-4, $F_{(2, 49)} = 3.933$, $p=0.026$ (Table 6). The Tukey post hoc test was used to determine if there were significant differences in the FSIQ between groups (Table 7). The mean difference (10.65 points) in the FSIQ-4 between the control and ADHD-C group were statistically significant, with the sample of ADHD-C scoring lower on the IQ tests. The mean difference in IQ between the control group and the ADHD-PI (7.82); and ADHD-PI and ADHD-C (2.82) were not statistically significant.

Correlation analyses were conducted to determine the extent of the relationship between age, IQ, and the dependent variables beyond group membership. Age was not significantly correlated with any of the dependent variables, as expected, given the narrow age range. However, as expected, significant positive correlations were found between FSIQ-4 scores and fluid reasoning, working memory capacity, written expression composite, and written expression subscores for ideas and development; organization, unity, and coherence; vocabulary; sentence structure and variety; grammar and usage; and capitalization and punctuation, as listed in Table 8.

Table 6

The Between Group Effects of Diagnosis on the Dependent Variables

	DF	F	p
Grade	2, 49	1.042	0.360
Age	2,49	0.915	0.407
FSIQ-4	2,49	3.933	0.026
Fluid reasoning	2, 49	1.456	0.243
Working memory	2,49	9.979	<0.001
Written Expression	2,49	8.265	0.001
Ideas and development	2, 49	11.057	<0.001
Organization, utility and coherence	2,49	9.531	<0.001
Vocabulary	2,49	6.513	0.003
Sentence structure and variety	2, 49	11.281	<0.001
Grammar and usage	2,49	9.187	<0.001
Capitalization and punctuation	2,49	4.902	0.012

Table 7

Tukey Post Hoc Tests for FSIQ-4 by Group

	ADHD-C	ADHD-PI
Control	10.65 (p=0.025)	7.82 (p=0.126)
ADHD-PI	2.82 (p=0.754)	

Table 8

Correlation Matrix of Dependent and Independent Variables

	1	2	3	4	5	6	7	8	9	10	11
1. FSIQ-4	1	.371**	.637**	.476**	-.266	.376**	.335*	.531**	.580**	.425**	.361**
2. WM		1	.264	.527**	-.134	.378**	.287*	.391**	.503**	.456**	.395**
3. FR			1	.264	-.201	.229	.196	.379**	.462**	.235	.316*
4. WE				1	-.204	.727**	.712**	.713**	.733**	.672**	.682**
5. Diagnosis					1	-.297*	-.299*	-.213	-.350*	-.263	.000
6. Ideas						1	.813**	.704**	.542**	.635**	.271
7. Organization							1	.695**	.508**	.537**	.346*
8. Vocabulary								1	.535**	.544**	.359**
9. Sentence									1	.607**	.607**
10. Grammar.										1	.518**
11. Punctuation											1

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Test of Hypotheses

Research Question One

Do children with ADHD:PI have more difficulty with tasks of written expression as measured by the written expression subtest of the WIAT-II than children in the ADHD:C and control groups?

Multivariate Analysis of Covariance (MANCOVA) was conducted to determine diagnosis differences (control, ADHD-C and ADHD-PI) on written expression as measured by the written expression quotient; ideas and development; organization, utility and coherence; vocabulary; sentence structure and variety; grammar and usage; and capitalization and punctuation, while controlling for the effects of FSIQ-4. Preliminary analyses indicated that the dependent variables (written expression quotient, ideas and development; organization, utility and coherence; vocabulary; sentence structure and variety; grammar and usage; and capitalization and punctuation) were intercorrelated suggesting the combined dependent variable could be considered a writing composite (Table 8). FSIQ-4 was shown to relate to the dependent variables, and was included as a covariate. MANCOVA was selected in order to protect against an inflated Type I error rate.

MANOVA results revealed significant differences among the diagnostic categories, Wilks' $\Lambda = 0.559$, $F_{(14, 82)} = 1.977$, $p=0.03$, multivariate $\eta^2 = 0.252$. The covariate (FSIQ-4) significantly influenced the combined dependent variable (DV), Wilks' $\Lambda = 0.661$, $F_{(7, 41)} = 2.999$, $p=0.012$, multivariate $\eta^2 = 0.339$. Analysis of covariance (ANCOVA) was conducted on each dependent variable as a follow-up test to

MANCOVA. ANCOVA results (Table 9) indicate that diagnosis significantly affected the outcome on written expression ($F_{(2, 47)}$ =4.915, p=0.012), partial η^2 = 0.173); ideas and development ($F_{(2, 47)}$ =7.510, p=0.001, partial η^2 = 0.242); organization, unity and coherence ($F_{(2, 47)}$ =6.587, p=0.003, partial η^2 = 0.219); vocabulary ($F_{(2, 47)}$ =3.253, p=0.048, partial η^2 = 0.122); sentence structure and variety ($F_{(2, 47)}$ =6.406, p=0.003, partial η^2 = 0.214); grammar and usage ($F_{(2, 47)}$ =5.710, p=0.006, partial η^2 = 0.195); and capitalization and punctuation ($F_{(2, 47)}$ =3.518, p=0.038, partial η^2 = 0.130).

Table 9
Univariate Analysis of Covariance for Written Expression and Written Expression Subtests

	Type III SS	MS	MSE	F	Sig.	Partial η^2
Analysis of Covariance Tests on each Dependent Variable						
Written expression	1362.432	681.216	138.599	4.915	.012	.173
Ideas and development	5.608	2.804	0.373	7.510	.001	.242
Organization	5.174	2.587	0.393	6.587	.003	.219
Vocabulary	2.039	1.019	0.313	3.253	.048	.122
Sentence structure	3.418	1.709	0.267	6.406	.003	.214
Grammar	3.335	1.667	0.292	5.710	.006	.195
Punctuation	3.769	1.885	0.536	3.518	.038	.130
Tests of the significance of the regression of the covariate on the dependent variable						
Written expression	1058.538	1058.538	138.588	7.638	.008	.140
Ideas and development	.921	.921	0.373	2.466	.123	.050
Organization	.597	.597	0.393	1.521	.224	.031
Vocabulary	3.626	3.626	0.313	11.573	.001	.198
Sentence structure	3.815	3.815	0.267	14.300	<.001	.233
Grammar	1.334	1.334	0.292	4.568	.038	.089
Punctuation	2.464	2.464	0.536	4.598	.037	.089

Means were adjusted for the covariate FSIQ-4. Adjusted and unadjusted group means for written expression are presented in Table 10. Pairwise comparisons, using individual T-tests, of adjusted means are presented in Table 11. Comparison of adjusted means for written expression indicates that both the control and ADHD-PI group had significantly higher written expression quotients (Figure 2) compared to the ADHD-C, with no significant difference between the ADHD-PI and control group. Significant group differences in written expression subscales were observed (Figure 3). The ideas and development scores of ADHD-PI and control groups were significantly higher compared to the ADHD-C group, with no significant difference between the ADHD-PI and control group. Control subjects have statistically significantly higher organization, unity and coherence; and sentence structure and variety scores compared to both the ADHD-C and ADHD-PI groups, with no statistically significant differences between the ADHD-C and ADHD-PI groups. The control group had statistically significantly higher scores for vocabulary, and grammar usage compared to the ADHD-C group, with no significant differences between the ADHD-C and ADHD-PI, or between the control group and ADHD-PI. ADHD-C had significantly poorer capitalization and punctuation compared to the ADHD-PI group, with no significant difference between the control group and ADHD-C or ADHD-PI groups.

Table 10
Adjusted and Unadjusted Means for FSIQ-4

Dependent Variable	Group	Adjusted Mean*	Unadjusted Means
Written expression	Control	105.83	108.35
	ADHD-C	92.78	90.94
	ADHD-PI	101.98	101.29
Ideas and development	Control	2.75	2.82
	ADHD-C	1.88	1.82
	ADHD-PI	2.31	2.29
Organization	Control	2.88	2.94
	ADHD-C	2.04	2.00
	ADHD-PI	2.43	2.41
Vocabulary	Control	2.56	2.71
	ADHD-C	2.05	1.94
	ADHD-PI	2.39	2.35
Sentence structure	Control	2.50	2.65
	ADHD-C	1.82	1.71
	ADHD-PI	2.10	2.06
Grammar	Control	2.38	2.47
	ADHD-C	1.71	1.65
	ADHD-PI	2.08	2.06
Punctuation	Control	2.23	2.35
	ADHD-C	1.74	1.65
	ADHD-PI	2.39	2.35

* Covariates appearing in the model are evaluated at FSIQ-4 = 111.90.

Table 11
Pairwise Comparisons of Group Differences in Adjusted Means of Written Expression

Dependent Variable	MD	SE	p[a]	Effect Size
Written expression (12.56)[b]				
Control and ADHD-C	13.052*	4.335	.004	1.039
Control and ADHD-PI	3.855	4.201	.363	0.307
ADHD-PI and ADHD-C	9.197*	4.060	.028	0.732
Ideas (.678)				
Control and ADHD-C	.871*	.225	<.001	1.285
Control and ADHD-PI	.435	.218	.052	0.642
ADHD-PI and ADHD-C	.436*	.211	.044	0.643
Organization (.630)				
Control and ADHD-C	.838*	.231	.001	1.330
Control and ADHD-PI	.453*	.224	.048	0.719
ADHD-PI and ADHD-C	.384	.216	.082	0.610
Vocabulary (.620)				
Control and ADHD-C	.510*	.206	.017	0.823
Control and ADHD-PI	.165	.200	.412	0.266
ADHD-PI and ADHD-C	.344	.193	.081	0.555
Sentence structure (.587)				
Control and ADHD-C	.679*	.190	.001	1.157
Control and ADHD-PI	.396*	.184	.037	0.675
ADHD-PI and ADHD-C	.284	.178	.118	0.484
Grammar (.557)				
Control and ADHD-C	.669*	.199	.002	1.201
Control and ADHD-PI	.298	.193	.129	0.535
ADHD-PI and ADHD-C	.371	.186	.052	0.666
Punctuation (.753)				
Control and ADHD-C	.496	.270	.072	0.659
Control and ADHD-PI	-.155	.261	.557	-0.206
ADHD-PI and ADHD-C	.650*	.252	.013	0.863

Based on estimated marginal means
* The mean difference is significant at the .05 level.
[a] Adjustment for multiple comparisons: Least Significant Difference
[b] Values in parentheses are pooled variance

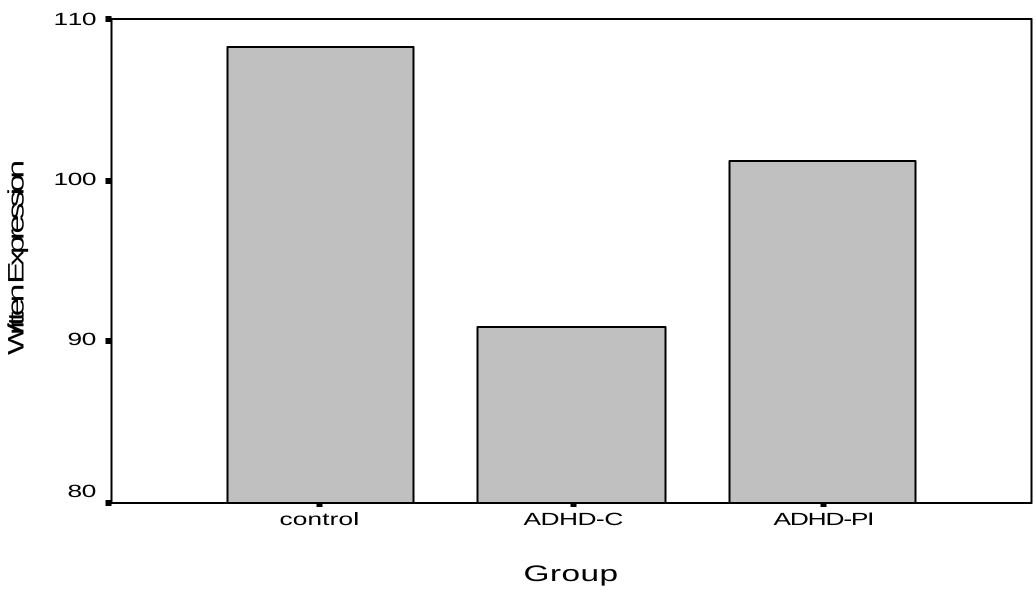


Figure 2. Adjusted Mean Written Expression Quotients by ADHD Group.

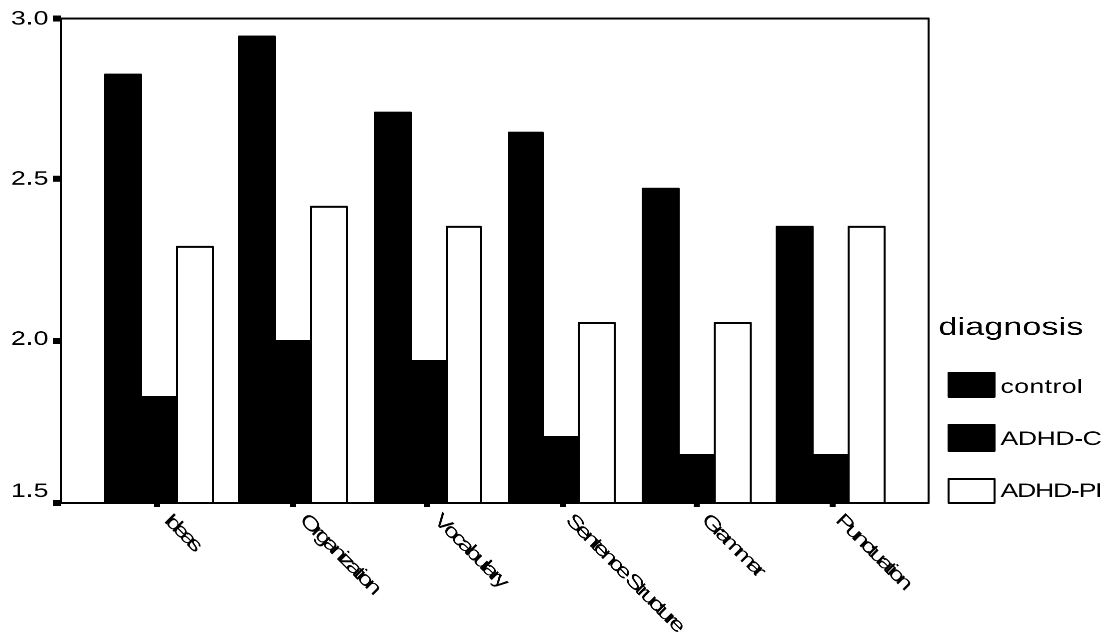


Figure 3. Comparison of Adjusted Mean Written Expression Subscales by ADHD Group Status

Research Question Two

Are there significant mean differences in the fluid reasoning (measured on the WJ-III fluid reasoning composite) and working memory (measured on the WISC-IV Working Memory Index) of children in different ADHD groups?

Preliminary analyses indicated that there was no significant correlation (r=.264, p=0.061) between fluid reasoning and working memory capacity. Univariate ANOVAs were conducted: a summary of the results are presented in Table 12 and Figure 4. Results indicate that diagnosis significantly affected working memory capacity, $F_{(2, 48)} = 9.979$, $p<0.001$, $\eta^2 = .294$. Fluid reasoning, on the other hand, does not significantly differ for diagnosis, $F_{(2, 48)} = 1.456$, $p=0.243$, $\eta^2 = .0.057$. Tukey post hoc (Table 13) results indicate that ADHD-C have statistically significantly lower working memory capacity scores compared to both the control and ADHD-PI groups, with no significant difference between the control and ADHD-PI groups. Comparison of means (Table 14) revealed that the working memory capacity of the ADHD-C group was more than 10 points lower than both the control or ADHD-PI groups.

Table 12
Analysis of Variance Summary Table for Executive Function and ADHD Status

	Type III SS	MS	F	Sig.	Partial η^2
Working Memory	2365.451	1182.725	9.979	<0.001	.294
Fluid Reasoning	589.922	294.961	1.456	0.243	.057

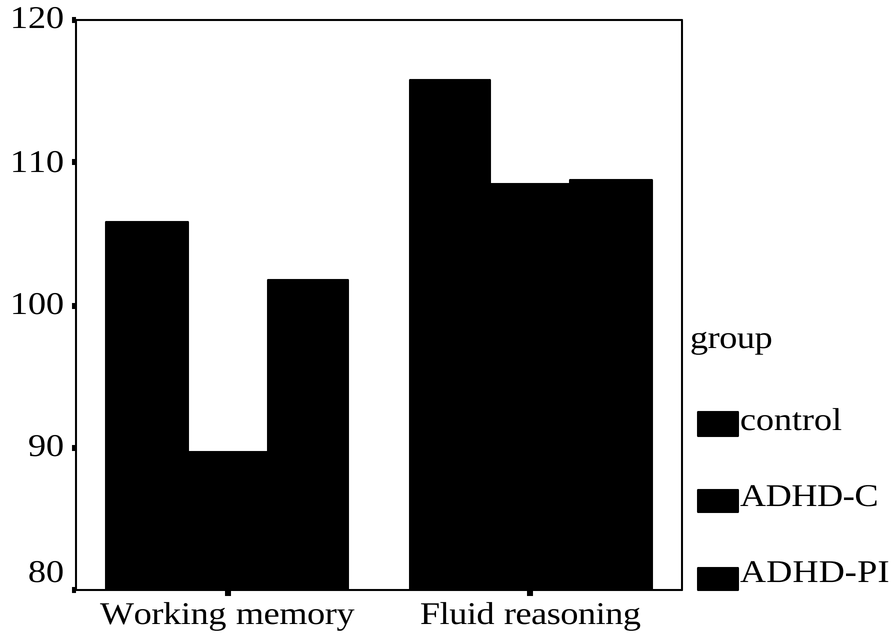


Figure 4. Fluid Reasoning and Working Memory Capacity by ADHD-Group Status

Table 13
Tukey Post Hoc Comparisons of Group Differences after Controlling for the Effects of FSIQ-4

	Mean Difference (I-J)	Std. Error	Sig.
Working Memory			
Control and ADHD-C	16.06*	3.734	<.001
Control and ADHD-PI	4.12	3.734	.517
ADHD-PI and ADHD-C	11.94*	3.734	.007
Fluid Reasoning			
Control and ADHD-C	7.41	4.881	.291
Control and ADHD-PI	7.00	4.881	.332
ADHD-PI and ADHD-C	.41	4.881	.996

Based on observed means.

Table 14
Adjusted and Unadjusted Group Means for Working Memory Capacity and Fluid Reasoning.

	Unadjusted Mean	Adjusted Mean[a]
Working memory		
Control	105.82	104.350
ADHD-C	89.76	90.840
ADHD-PI	101.71	102.105
Fluid reasoning		
Control	115.82	111.158
ADHD-C	108.41	111.814
ADHD-PI	108.82	110.086

[a] Evaluated at covariates appeared in the model: FSIQ-4 = 111.90

<u>Research Question Three</u>

How accurately does fluid reasoning and working memory capacity predict written expression?

A hierarchical multiple regression analysis was conducted to determine how well the independent variables (fluid reasoning and working memory capacity) could predict overall written expression. The written expression quotient was entered as the criterion variable and FSIQ-4, and fluid reasoning and working memory capacity composites were entered as the predictor variables of overall performance on written expression. Data screening did not indicate any significant outliers, and all cases were retained. Tolerance tests for multicollinearity of the FR and WM indicated that WM and FR were not highly correlated (tolerance of .861, and .593 respectively), and both WM and FR were included as the predictor variables. Given the exploratory nature of this question, full scale IQ (FSIQ-4) was entered in step one, followed by a sequential block entry of fluid reasoning and working memory capacity in step two, to predict written expression. The effects of fluid reasoning and working memory capacity represent the effects of these variables together, above and beyond FSIQ.

The regression analysis supported this hypothesis. An overall model of three predictors (FSIQ-4, fluid reasoning and working memory capacity) significantly predicted written expression, $R^2 = 0.373$, R^2 adjusted = 0.333, $F_{(3, 47)} = 9.316$, $p<0.001$ (Tables 15 and 16). This model accounted for 37.3% of the variance in written expression scores. FSIQ-4 accounts for 22.6% of the variance in written expression, with WM accounting for an additional 14.7% of the variance. Bivariate and partial correlation coefficients between each predictor and the dependent variable, are presented in Table 17. A summary of the regression model is presented in Table 15, and indicates that only FSIQ-4 and working memory capacity significantly contributed to the model (Figure 5).

Table 15
Regression Model for Variables Predicting Written Expression Performance (N=51)

Model	R	R^2	F	p	df
1	.476(a)	.226	14.332	>0.001	1,49
2	.611(b)	.373	9.316	>0.001	3,47

a Predictors: (Constant), FSIQ-4
b Predictors: (Constant), FSIQ-4, WM
c Dependent Variable: written expression

Table 16
Analysis of Variance Summary Table for Written Expression with FSIQ-4, WM and FR

	Sum of Squares	df	$Mean^2$	F	Sig.
Regression	3796.232	3	1265.411	9.316	.000[a]
Residual	6383.808	47	135.862		
Total	10180.039	50			

[a] Predictors: (Constant), FSIQ-4, WM Dependent Variable: Written Expression

Table 17
Summary of Sequential Regression Analysis for Variables Predicting Written Expression (N=51)

					Correlation		
	B	Beta	t	Sig.	Zero-order	Partial	Tolerance
FSIQ-4	.445	.378	2.424	.019	.476	.333	.550
WM	.460	.409	3.286	.002	.527	.432	.861
FR	-.084	-0.84	-.562	.577	0.264	-.082	.593

a Dependent Variable: WIAT written expression

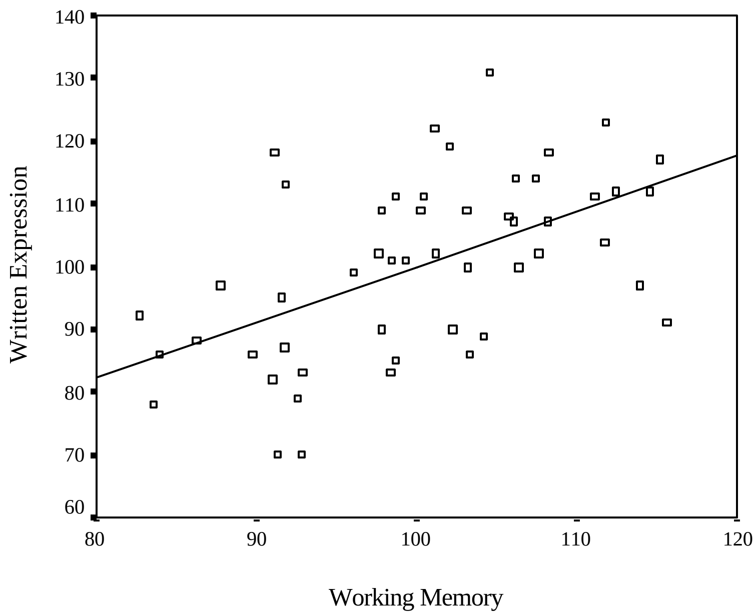


Figure 5. Multiple Regression Analyses for the Prediction of Written Expression from Working Memory

Exploratory Analyses

The main analyses indicated an unexpected reversed directional trend of the ADHD-C group performing poorer on the dependent variables of written expression and working memory capacity compared to the ADHD-PI group. An exploratory analysis indicated that the number of disinhibition symptoms endorsed in the ADHD-PI sample ranged from 0 to 5, with a mean of 2.47, and standard deviation of 1.5. Given the relatively high endorsements of disinhibition in the ADHD samples, a preliminary analysis was conducted to determine if the symptoms of disinhibition were correlated with working memory capacity and written expression (Table 18). Significant negative correlations between the hyperactive/impulsive symptoms ratings on the SIDAC with written expression ($r = -0.488$, $p<0.001$) and working memory capacity ($r = -.505$, $p<0.001$) were found, indicating an association between higher hyperactivity/impulsivity ratings and lower scores on written expression and working memory capacity.

Table 18
Summary of Linear Regression Analysis for Disinhibition Predicting Working Memory Capacity and Written Expression (N=51)

	B	Beta	t	Sig.	Zero order correlations
Working memory	-2.296	.560	43.473	<.001	-.505**
Written expression	-2.493	-.488	-3915	<.001	-.408**

a Dependent Variable: WIAT written expression and WM.

** Correlation is significant at the 0.01 level (2-tailed).

Exploratory analyses were conducted using simple linear regression to explore the following question: Does disinhibition, as measured on the SIDAC, predict written expression and working memory capacity scores. The hyperactive and impulsive symptom scores of the SIDAC were combined to form a new variable, disinhibition. Disinhibition was entered as the criterion variable, and working memory capacity and written expression were entered as the predictor variables. Data screening did not indicate any significant outliers, and all cases were retained. Regression results indicate that disinhibition significantly predicted working memory capacity, $R^2 = .255$, R^2_{Adjusted}

= .240, $F_{(1,49)}$ = 16.805, p<.001, and accounted for 25.5% of the variance in working memory capacity. Disinhibition was also found to significantly predict written expression, R^2 = .238, R^2_{Adjusted} = .223, $F_{(1,49)}$ = 15.330, p<.001, and accounted for 23.8% of the variance in written expression. A summary of the regression model is presented in Table 19, and the ANOVA summary table is presented in Table 20.

Table 19
Regression Model for Variables Predicting Working Memory Capacity and Written Expression Performance (N=51)

Model	R	R^2	R^2 Adj	SEE
Working Memory	.505(a)	.255	.240	11.063
Written Expression	.488(a)	.238	.223	12.580

a Predictor: Disinhibition

b. Dependent Variable: Written Expression and Working Memory Capacity

Table 20
Analysis of Variance Summary Table for Disinhibition with Working Memory Capacity and Written Expression

	Sum of Squares	df	$Mean^2$	F	Sig.
<u>Working Memory</u>					
Regression	2056.911	1	2056.911	16.805	<.001
Residual	5.997.598	49	122.400		
Total	8054.510	50	(7.284)		
<u>Written Expression</u>					
Regression	2425.902	1	2425.902	15.330	<0.001
Residual	7754.137	49	158.248		
Total	10180.039	50	(10.323)		

[a] Predictors: (Constant), Disinhibition

Dependent Variable: Working Memory Capacity

CHAPTER 5

Discussion

Chapter 5 is divided into two major sections. The first section is organized around the goals of the study, and the findings in reference to the three major hypotheses. Second, the results of initial and post hoc analyses were considered in the context of existing research. The limitations of this study are also addressed in this section. The final section, Conclusions and Future Directions, focuses on how the findings may inform future research and clinical efforts.

Summary and Integration of Findings

In this study, I explored whether fluid reasoning and working memory capacity differences affect written expression of children with and without attention deficit hyperactivity disorder. The written expression, fluid reasoning and working memory capacity of children between the ages of the 9 and 14 with ADHD-PI, ADHD-C, and normal healthy controls were compared. Differences in working memory capacity and written expression were found between children with and without ADHD. The findings of this study are discussed below.

The quality of the written expression of individuals with ADHD-C was found to be less well developed compared to children without ADHD or with the inattentive type of the disorder (ADHD-PI). Specific differences in written expression indicated that children with ADHD-C generated fewer ideas, and provided fewer supporting thoughts and elaborations for the ideas presented compared to both the control and ADHD-PI groups. Both groups of children with ADHD (ADHD-C and ADHD-PI) showed significant deficits in overall organization, coherence, and unity in their writing, indicating a qualitative weakness in the arrangement, planning, and connecting of ideas compared to the control group. The ADHD sample (ADHD-C and ADHD-PI) also had less varied sentence construction compared to children without ADHD. Individuals without ADHD choose more appropriate, vivid and precise language to convey meaning compared to children with ADHD. The ADHD-C group demonstrated poorer conformity to the rules of Standard English for written discourse compared to the control group. Compared to the ADHD-PI group, the ADHD-C group had significantly inferior usage of the mechanics of written language (i.e., punctuation and capitalization).

The findings of this study partially confirmed the hypothesis with a finding of differences in written expression performance among groups. However, the hypothesis of differences between the ADHD-PI and ADHD-C groups with the ADHD-PI performing poorer on the written expression measure was not supported. An unexpected directional difference in written expression performance was found. Individuals with the combined type of the disorder (ADHD-C) had poorer performance on tasks of written expression compared to both the control and ADHD-PI groups.

The findings from this study revealed that working memory capacity (WMC) was significantly lower for the ADHD-C group compared to both the control and ADHD-PI groups. Working memory capacity was found to be a good predictor of performance on written expression tasks. Individuals with higher working memory capacity scores were more likely to have higher written expression scores, compared to individuals who had lower working memory capacity scores.

No differences in fluid reasoning (FR) were found among the three groups. This study rejected the null hypothesis of no difference in the WM and FR among the groups. This study failed to support the directional hypothesis that the ADHD-PI group would have a poorer performance on tasks of working memory capacity compared to the ADHD-C group. The results of this study indicate significant between group differences in working memory capacity, with the ADHD-C group performing poorer on working memory capacity tasks compared to the ADHD-PI group.

The findings of this study suggest that performance differences in written expression are related to working memory capacity in children with ADHD. There is an expanding body of research data to indicate that written expression is an executive function task (e.g., Hayes & Flower, 1980, 1986; Kellogg, 1996). Additionally, there is growing consensus (e.g., Barkley, 1997a, 2001; Castellanos & Tannock, 2002) that ADHD-C is associated with executive function deficits. The findings of this study indicate an association between deficits in the executive function of working memory capacity in children with ADHD-C and their performance on written expression tasks.

Discussion

Written expression has been viewed as an executive function task in a number of theoretical models (Hayes, 1996; Hayes & Flower, 1980, 1986; Kellogg, 1996). Specific focus has been directed towards the role of working memory capacity in the writing process (Berninger et al., 2006; Fayol, 1999), with emergent research on the role of a wider array of executive functions on written expression (Hooper et al., 2002). However, there is a paucity of research on the role of fluid reasoning on written expression. The present study is one of the first to examine the contributions of both fluid reasoning and working memory capacity to the writing process. Using a conceptual model of an executive function deficit hypothesis in ADHD (Barkley, 1997a); this study examined the contributions of working memory capacity and fluid reasoning on written expression.

ADHD and written expression

Findings from this study revealed that ADHD status significantly affected written expression. Both ADHD groups had poorer organization and sentence structure compared to the control group, suggesting some difficulty with the executive functions of organization and cognitive flexibility on tasks of this nature. Contrary to expectations, the ADHD-C Group had significantly lower written expression scores, and specifically idea generation, compared to the ADHD-PI and control groups. Furthermore, the ADHD:PI Group demonstrated significantly better punctuation skills compared to the ADHD:C Group. The ADHD:C group also demonstrated significantly poorer vocabulary selection and use of writing conventions (grammar skills) compared to the control sample. These findings were not consistent with results from other researchers who reported an association between the inattentive type of ADHD with academic difficulties (DuPaul, Power, Anastopoulos, & Reid, 1998; Fischer et al., 1993b; Lahey et al., 1994). The findings from this research are most likely an extension, rather than being a contradiction, of previous research. Previous research focused on math and reading difficulties, with this study being one of the first to address written expression in this population. Given that findings of this study are specific to written expression, direct comparisons with previous research would lead to spurious conclusions, since a comparison of written language with math or reading would fail to account for the underlying constructs of these tasks. Previous research findings have indicated that children with ADHD-PI have greater academic underachievement, particularly in math (Hynd et al., 1991; Marshall et al., 1997; Morgan et al., 1996), and were more likely to be in special classes for students with learning disabilities (Faraone et al., 1998). However, samples sizes in these studies were small and statistical power was low. Alternately, other researchers have reported no difference in the academic performance of individuals in the different ADHD groups (Casey, Rourke, & Del Dotto, 1996). There is a paucity of research data to corroborate the findings of higher rates of academic impairment among the ADHD-C group compared to the ADHD-PI group. The findings of the relationship between ADHD-C and deficits in written expression are significant and noteworthy because this is an extension of research on the relationship between ADHD and academic functioning. The significant group differences that were uncovered generally had small effect sizes, indicating that there was much more variance to be explained than was accounted for by the diagnosis of ADHD alone.

ADHD Subtypes and Academic Performance.

Research on the subtypes of ADHD is complicated by the ambiguity in diagnostic criteria, given that a consensual shift occurred when classification criteria for ADHD were refined in 1994 (American Psychiatric Association, 1994). The inattentive type of the disorder has only been diagnosed since the fourth edition of the Diagnostic and Statistics Manual (DSM-IV), and the criteria for the combined and hyperactive/ impulsive types of the disorder were restructured. Thus, a comparison of results from older studies (e.g., Fischer et al., 1993b; Hynd et al., 1991; Lahey et al., 1994) with recent studies (e.g., Faraone et al., 1998; Hooper et al., 2002) needs to be viewed with caution.

Although there is current consensus in the criteria for the classification of the inattentive subtype of the disorder, existing classification criteria encompass individuals who range from having no hyperactive/impulsive symptoms to those who just fail to meet the threshold for the combined type of the disorder. The diagnosis of ADHD-PI is further compounded by the argument that individuals with and without hyperactive/impulsive symptoms may represent qualitatively different diagnoses (Barkley, 1998, 2001; Milich et al., 2001). In the present study, hyperactive/impulsive symptoms ranged from none to five in the ADHD-PI sample, suggesting that the presence of disinhibition symptoms may explain some of the variance in written expression. The association between hyperactive/impulsive symptoms ratings on the SIDAC with written expression was significant, indicating that higher levels of disinhibition were associated with lower scores on written expression.

In the present study, the ADHD-C sample had significant inattention and disinhibition symptoms, and had to meet the threshold criteria for inattention compatible with a diagnosis for ADHD-PI. These diagnostic criteria for ADHD-C suggest that ADHD-C is a more severe form of the disorder, potentially increasing the overall detrimental effect on performance. Diagnosis of ADHD is dependent upon behavior reports, which in turn affect both the placement and remediation of the ADHD population (Barkley, Fisher, et al., 1990; Barkley, Anastopoulos, Guevremont, & Fletcher, 1991). There is an emerging research data (Barkley, Fischer, et al., 1990; Barkley et al., 1991) and theory (Rapport, Scanlan, & Denney, 1999) to indicate that the overall academic outcome of children with ADHD may have to do with placement and resource allocation. It is interesting to note that Barkley et al. (1990) found that the ADHD-C group had significantly higher teacher and parent endorsements of inattentiveness compared to the ADHD-PI group, suggesting significant problems with attention among the ADHD-C population. Furthermore, it has been postulated that conduct problems in the classroom may predispose ADHD populations to academic underachievement, adversely impacting productivity and general school performance (Rapport et al., 1999). Children with ADHD-PI were found to have additional problems with completing work (Lahey et al., 1994) and were more likely to have impaired academic achievement (DuPaul et al., 1998; Fischer et al., 1993b). Thus, it is likely that the association between ADHD-C and lower scores on written expression in the current study may be related to the effect of impulsivity and working memory capacity on school performance in the ADHD-C group, compared to the ADHD-PI or control groups.

ADHD, Executive Functions and Written Expression

A second major issue confronting this study relates to the association between written expression and ADHD with executive function. As noted earlier, written expression is postulated to be mediated by executive functions (Berninger et al., 2006; Hayes, 1996; Hayes & Flower, 1980, 1986; Kellogg, 1996), and the current study aligned with the conceptual model of an executive function deficit hypothesis of ADHD (Barkley, 1997; Biederman et al., 2004; Oosterlaan, Scheres, & Sergeant, 2005; Pennington & Ozonoff, 1996, Seidman et al., 1997). There undoubtedly was some bias towards focusing on disinhibition, rather than inattention, since the executive function deficit hypothesis of ADHD proposes that behavioral disinhibition is a primary deficit in the combined type of ADHD. The executive dysfunction theory does not explain the inattentive subtype of the disorder (Barkley, 1997a). The findings from the current study indicated significant deficits in working memory capacity in the ADHD-C group compared to the control or ADHD-PI groups, supporting the executive dysfunction hypothesis for ADHD-C. These findings are also consistent with the relationship between ADHD and working memory capacity described by other researchers (Barkley, 1997b, 2003a; Castellanos & Tannock, 2002), and extend the work beyond working memory capacity to include fluid reasoning.

The findings of the current study indicated that fluid reasoning (FR) did not differ significantly between groups. There is a moderately high correlation between fluid reasoning and FSIQ-4 in the current sample ($r=.637$, $p<0.001$), indicating that the variance in fluid reasoning in the sample is best explained in terms of the FSIQ-4 differences between groups. The fluid reasoning abilities of inductive, deductive, conjunctive and disjunctive reasoning used in the Analysis-Synthesis and Concept Formation subtests appears to measure different constructs from the working memory capacity tasks of digit span and letter number sequencing. These data suggest that working memory capacity and fluid reasoning, as measured in the current study, are distinct constructs, corroborating current consensus that WM and FR are separate constructs (Ackerman et al., 2002; Colom et al., 2003; Conway et al., 2002; Engle et al., 1999). The common variance of 7% shared between WM and FR ($F(1,49)=3.671$, $p=0.061$) in the current study is much lower than reported in the literature, which range from 20% to 65% (Ackerman et al., 2002; Colom et al., 2004; Engle et al., 1999; Sut et al., 2002). It is interesting to note that although both the working memory capacity and fluid reasoning tasks were affected by controlled attention, these data suggest that cognitive speed, concentration and carefulness appear to be more compromised by disinhibition. Another major difference between the current study and previous research is the careful diagnostic criteria that were applied as well as the exclusionary criteria prohibiting additional diagnoses such as a learning disability. Much of the previous literature has included children with varying comorbid diagnoses thus clouding the interpretation of the results. One of the strengths of this study is that no comorbid diagnoses were accepted.

Written Expression as an Executive Function Task

Findings from this study revealed that working memory capacity significantly differentiated good writers from poor writers. These findings were consistent with the hypothesized relationship between working memory capacity and writing, and are generally consistent with results previously described by researchers (Abbott & Berninger, 1993; Kellogg, 2001). The findings also extend the work from other researchers (Abbott, & Berninger, 2006; Altemeier, Jones, Abbott, Berninger, 2006; Graham et al., .1997; Kellogg, 2001; McCutchen, 2000) beyond working memory capacity and written expression, and include fluid reasoning. In this sample, however, fluid reasoning did not significantly differentiate good writers from poor writers, indicating that factors other than fluid reasoning affected writing performance in this sample. On the other hand, the combined model using both FR and WM were good predictors of written expression, and explained 14.7 % of the variance in written expression when the effects of FSIQ-4 were controlled. These findings are consistent with those reported by Hooper et al., (2002) who reported a positive association between executive functions and written expression.

Written Expression and Working Memory Capacity.

There has been a convergence and extension of findings in this study indicating that working memory capacity differences between ADHD-C and ADHD-PI groups affect overall written expression. Deficits in working memory capacity and long term memory have been implicated in lower writing ability (Berninger, 1999; Lea & Levy, 1999). The retrieval and organization of multiple types of information that is concurrently necessary for the successful production of writing depends on effective working memory (Roth, 2000). Given that the writer also has to draw on long term memory to produce both the content and form of the written product, working memory is the cognitive workspace that manages and facilitates the active maintenance of multiple ideas, retrieval of grammar rules from long term memory, and the recursive self monitoring that is a characteristic of superior writing ability (Kellogg, 1996, 1999; McCutchen, 1996; Swanson & Berninger, 1994). The current study corroborates the accruing body of research data that indicates that deficits in working memory result in problems with written expression (Fayol, 1999; Lea & Levy, 1999).

In the current study, the overall quality of the writing task was lower for the ADHD groups. A qualitative examination of the written product revealed that individuals with ADHD demonstrated fewer of the characteristics of good writers. Good writers generate more ideas, translate them into a well written form, use higher order processes that include planning, organizing, self monitoring and revising (Hayes & Flower, 1980; Graham & Harris, 1999; Hooper, Temiyakan, & Williams, 1993). Individuals with ADHD characterized by executive function deficits, have difficulty with sustained attention towards task performance, controlled impulses, regulation of activity level, and consistent production of work. They also experience a decline in performance as the complexity of the task increases (Douglas, 1983).

There is a body of research data that indicates that children with ADHD have poorer working memory capacity (Barkley, 1997a; Murphy, Barkley, & Bush,. 2001; Zentall & Smith, 1993). A similar reduction in working memory capacity has been found when poor writers are compared to expert writers (McCutchen, 1996). In the current study, working memory capacity was the strongest predictor of written expression. Working memory capacity was also associated with ADHD status, with the ADHD-C group having significant deficits in working memory capacity compared to the ADHD-PI and control groups. Furthermore, the ADHD-C group had a significantly poorer performance on written expression tasks compared to the control and/or ADHD-PI group. These data suggest that ADHD-C is negatively associated with working memory capacity, which in turn affects written expression, implying that the differences in written expression may be related to working memory capacity deficits in the ADHD-C sample.

Limitations

In order to ensure the robustness of this study, precautions were taken to guard against, and account for, errors associated with human variability, constraints of measurement instruments, and the use of obtained scores as proxies for ability and achievement. However, as with any research, there are a number of limitations in the current study that need to be addressed. Given that these limitations affect the results of this study, the results must be interpreted with caution. The calculated values for effect size in this study were very small and did not account for more than 2% of the variance. Although significant, this places considerable limitations on the ability to interpret these findings in relation to the general population. Sampling variation, diagnostic classification criteria, and sample size are some of the factors that could potentially limit effect size in this study.

First, the DSM-IV criteria for the diagnosis of ADHD states that behavioral difficulties have to be corroborated by two or more people, and symptoms have to be evident in two or more settings. Given that behavioral difficulties and challenges are situation specific, obtaining consensus among different reporters from different settings is difficult. Teachers routinely report higher rates of behavioral difficulties compared to parents because of the greater demands for attention and inhibition in classroom environments (DuPaul et al., 1998). Notwithstanding, test validity measures indicate a 90% congruence between parent and teacher endorsement of clinical symptoms that lead to a diagnoses of ADHD (Biederman, Keenan, & Faraone, 1990). Getting corroborating reports from the same individual is also problematic (Barkley, 1997a, 2001). In this study, parent ratings of hyperactivity/impulsivity and attention were obtained using parent interviews (SIDAC) and reports (BASC) that were administered on the same day. Diagnostic classification was based on the congruence of hyperactive/impulsive and attention symptoms on both measures. Parent reports, however, did not always concur with parent interviews, resulting in approximately 30% of participants failing to meet the diagnostic criteria due to incompatible scores on either measure. Barkley (2001) has proposed that merging parent and teacher ratings to obtain a holistic assessment of the behavioral functioning of the child would be most prudent. However, there are some emergent findings to indicate that confirmatory endorsement of symptoms by both parent and teacher reports provide the best discrimination of children with and without ADHD

(Crystal, Ostrander, Chen, & August, 2001). The variability of the sample in the current study was reduced by careful diagnosing of ADHD, and limiting the range of ADHD participants.

Second, the assessment of written expression is subjective and is affected by both participant and assessor factors. The use of a single score to assess writing ability is not a robust measure of writing achievement, providing a time and situation limited vista of performance. In the present study, the written expression task was an extension of the traditional single narrative passage writing task used to assess written expression (Hooper et al., 2002; Swartz et al., 1999), increasing the breadth of the areas assessed. The writing task included verbal fluency; the generation and production of complex sentences, and passage writing. Writing prompts differed for children in grades 3 to 6 (descriptive narrative passage) from that of children in grades 7 to 9 (argumentative letter), demanding more organizational and formal writing skills for children in grades 7 to 9.

Despite the precautions taken to increase the accuracy of the assessment of written expression, overall performance was affected by individual variability of both the participant and assessor. Participant variables of motivation, compliance, overall skill level, and situational variables (environment, time of day, and biological states) affected performance on the writing tasks. These variables are consistent with what is generally seen in the classroom and thus lend credence to these findings as being likely representatives of the child's performance in the classroom. Assessor factors of subjectivity and skill in the assessment of written language decreased the robustness of the measure. The use of global writing constructs, as is used in the WIAT-II, to assess writing decreases the subjectivity of assessment (Muenz, Ouchi, & Cole, 1999). One of the difficulties with assessing written language is the instrumentation and the inability to directly measure important constructs (ideas and development; organization, unity and coherence; vocabulary; sentence structure and variety; grammar and usage; and capitalization and punctuation) with a standardized score rather than qualitatively.

The third major limitation is the effect of undiagnosed affective disorders on working memory capacity and academic performance. Barkley, DuPaul, and McMurray (1990) suggests that attention problems may predispose children to a greater risk of internalizing and externalizing problems. The rates of comorbid anxiety and mood disorders in ADHD populations range from 10% to 40% for anxiety (Tannock, 2000) to 15 to 75% for depression (Biederman, Faraone, Keenan, & Tsuang., 1991). Comorbidity of an affective disorder with attention difficulties affect focused attention, concentration and organization. The symptoms of anxiety, depression and ADHD interact with each other, exacerbating the effects of the other. Given the dynamic coexistence of these conditions, it is difficult to tease out the cause of the symptoms observed, making a differential diagnosis of ADHD versus an affective disorder very complicated. Hence, participants in this study may have had subclinical internalizing difficulties that were not of sufficient intensity to be recognized by the parent interviews or rating forms. Given the relationship between affective disorders on both working memory capacity and academic performance, the influence of subclinical affective disorders on the outcome variables cannot be ruled out.

Fourth, fluid reasoning, as measured in the current study did not have a significant correlation with working memory capacity ($r=.264$, $p=0.61$). Correlations between working memory capacity and fluid reasoning have been reported to range from 20% to

65%, discussed earlier. The lack of association between fluid reasoning and working memory capacity in the current study may be related to the underlying constructs of the working memory capacity and fluid reasoning tasks used to assess these domains. Fluid reasoning was assessed using the Analysis-Synthesis and Concept-Formation subtests which are novel reasoning, learning tasks. Other studies, however, have used a wider array of tasks to assess executive functions and fluid reasoning such as the Hanoi Tower and Wisconsin Card Sort. Working memory capacity was assessed using the Digit Span and Letter-Number Sequencing subtests that are relatively simple working memory capacity tasks of short duration. Working memory capacity tasks with higher cognitive loads, such as the Arithmetic subtest from the WISC-IV, have been used in other studies. The findings regarding the correlation between working memory capacity and fluid reasoning are two pronged. On one hand, it is likely that the lower association between fluid reasoning and working memory capacity may be due to the selection of measures. This finding would suggest that the association between fluid reasoning and working memory capacity could potentially be enhanced if another set of tests were used to assess these dimensions. The use of the fluid reasoning index from the WJ III may have limited the interpretation of the results of the study. On the other hand, it is very alluring to assume the lower correlation between fluid reasoning and working memory capacity in the current study are not spurious but reflect an effective reduction of the common variance between working memory capacity and fluid reasoning. The relationship between the fluid reasoning and working memory capacity constructs used in this study warrant further investigation.

The classification of ADHD subtypes (discussed earlier) is a major issue in the literature, and this study is no exception. Given the variability in the number of hyperactive/impulsive symptoms in the current ADHD-PI sample, and current discourse that ADHD-PI with and without disinhibition may be categorically different disorders (Milich et al,. 2001), the group identified as ADHD-PI in the current study may in fact represent two distinct conditions. Despite theoretical conjecture, there is little empirical evidence to separate out these categories. Thus, the diagnostic criteria outlined in the DSM-IV were used for classification in this study. The separation of the ADHD-PI with no hyperactivity/impulsivity and the ADHD-PI with hyperactivity/impulsivity, however, may have produced different results, potentially increasing the observed effect size between diagnosis and written expression or working memory capacity.

Final limitations of the study involve the comparatively low number of subjects available for correlation purposes when examining the combined data collected for each group. First, correlational studies do not convey cause and effect, but merely indicate a trend. Thus, the results of this study cannot be viewed in terms of cause and effect but must be interpreted as observed trends. Second, the strength of the observations is limited by sample size. Large sample sizes increase the robustness of observed trends. The power of the estimates, alternatively, can be increased by increasing the homogeneity of the sample. In this study, age and grade range were limited, and comorbid learning disabilities were excluded. The exclusion of these disabilities provided a cleaner sample but also one that may be less representative of the ADHD population as a whole. Moreover, the sample included a mixture of elementary, middle and some high school aged participants. Further refinement of the age and grade range of participants would help to increase the homogeneity of the sample.

Conclusions

In summary, the results of this study indicated IQ, working memory capacity and written expression differences between individuals with and without ADHD. The ADHD groups scored lower on these measures. However, when the performance of the ADHD sample was examined, these differences were related to the subtypes of ADHD, but could not be explained by diagnostic status alone. The combined type of the disorder was associated with significantly greater deficits. These differences in functioning appear to be related to the symptoms of disinhibition rather than attention. First, performance on tasks of written expression was related to ADHD status. Second, working memory capacity differences were associated with ADHD status. Finally, written expression was correlated with working memory capacity. Working memory and written expression performance, however, were related to disinhibition. Thus, it appears that the ADHD, characterized by disinhibition, was associated with deficits in working memory capacity which, in turn, relate to performance on written expression tasks.

In conclusion, this study contributed to neuropsychology literature by being one of the first to demonstrate an association between working memory capacity, written expression and ADHD. It also demonstrated an association between disinhibition and performance on working memory capacity and written expression tasks beyond ADHD status, suggesting that the working memory capacity and written expression difficulties in ADHD populations may be due to problems with disinhibition more so than by problems with inattention. The results of this study make a positive contribution for the intervention and remediation of ADHD, and offer new directions in which to focus research, therapies and interventions to address the academic and cognitive deficits associated with ADHD.

Directions for Future Research and Clinical Implications

A major detractor in research on ADHD, and this study was no exception, is related to the ambiguity of diagnostic criteria for ADHD-PI. There is a need to clarify implications and functional qualities, if any, between individuals with and without disinhibition symptoms. In addition to this trend of research, a qualitative comparison of the functional abilities of individuals with and without symptoms of disinhibition would need to be clarified. Revisiting the dependent variables (working memory capacity, fluid reasoning and written expression) of the current study, with regards to the ADHD-PI subtypes would be necessary to distinguish if functional differences between ADHD-PI populations with and without symptoms of disinhibition exist.

Using especially designed working memory capacity tasks that tap into specific language based deficits would provide a correlation between working memory capacity and written expression. The working memory capacity tasks (Digit span and Letter-Number Sequencing) used in this study do not replicate the complex working memory capacity demands of a written expression task. Thus, the development of tasks that assess verbal working memory capacity would be important to obtain a truer reflection of the influence of the working memory capacity on written expression. Hooper et al. (2002) developed a task assessing verbal organization efficiency using a writing component (described in Hooper et al., 2002) that was purported to tap into the verbal working memory capacity skills that are activated during the writing process. However, the validity and reliability of this measure has not been ascertained. Thus, refinement of this task and development of similar tasks would help to extend both research and knowledge of task-specific working memory capacity requirements.

Written expression is a complex activity that is affected by individual and situational variables. Thus, using a single measure of written expression fails to address the breath of the demands of written expression tasks. Attempts to extend the evaluation of written expression have focused on a formal assessment of specific writing components such as spelling, mechanics and grammar skills. Knowledge of the components of written expression does not necessarily translate efficiently into the written product. Writing portfolios that include representative samples of functional written expression (e.g. note taking, report writing, and written responses to test questions) may provide better estimates of written expression. Getting a representative writing sample for evaluation in clinical settings, on the other hand, presents new challenges. Thus, the development of measurement instruments that allow for the assessment of both functional and formal written expression is an area that needs further research.

The cognitive impulsivity of children with ADHD affects controlled and sustained attention to tasks. In the present study, cognitive impulsivity appears to be negatively associated with working memory capacity and performance on written expression tasks, beyond differences in ability. Given the potential effects of cognitive impulsivity on the functioning of individuals with ADHD, the development of intervention strategies to decrease the symptoms of cognitive impulsivity in the ADHD population may increase the outcome variables. Developing interventions geared towards educational environments would have implications for teaching and learning.

The traditional classroom relies on a lecture type format that does not facilitate the individualization of the learning environment. This passive engagement of the learner is particularly challenging for individuals who experience difficulty with inhibition, increasing the incidence of disruptive behaviors. Thus, the disinhibited individual is more likely to be placed on a behavioral management program that oftentimes include isolation and out of class placements. These placements decrease instruction time and exposure to content matter, compounding the learning deficits that are seen in this population. Restructuring the teaching-learning environment to optimize the interaction and participation of the learner and concomitantly increasing the individualization of the curriculum will allow the learner to shift between tasks and progress at his or her own rate. The availability of a wide range of instructional technology, such as the Inspiration Software, provides multimodal resources for the learner, parents and teachers, and focuses on specific deficits. Further investigation of the efficacy of alternative instructional methods and the implementation of technology for ADHD populations will help to direct appropriate instruction for this population.

Written expression is a fundamental component of academic success. Given that writing is a multidimensional complex executive function task, deficits can occur in a variety of areas. Thus, the individualization of writing instruction would facilitate addressing specific deficits. Several instructor resources are available to address the components of written expression. Self-regulation, content knowledge, and motivation have been identified as necessities for skilled writing (Harris, Graham, & Mason, 2003).

The Self-Regulated Strategy Development (SRSD) in Writing developed by Graham and Harris (Harris et al., 2003) is a method that provides systematic instruction, focusing on the executive functions necessary for skilled writing. Exploring the efficacy of instruction directed at developing skill specific executive functions for ADHD populations would offer new insights in the teaching and learning of this population.

APPENDICES

Appendix A: Informed Consent to Participate in Research

IRB APPROVED ON: 2/3/2006 ***EXPIRES ON 1/22/2007***

IRB#_01-04-22

Informed Consent to Participate in Research

The University of Texas at Austin

You are being asked to participate in a research study. This form provides you with information about the study. The Principal Investigator (the person in charge of this research) or his/her representative will also describe this study to you and answer all of your questions. Please read the information below and ask questions about anything you don't understand before deciding whether or not to take part. Your participation is entirely voluntary and you can refuse to participate without penalty or loss of benefits to which you are otherwise entitled.

Title of Research Study: Assessment of social competence in children with developmental disorders

Principal Investigator(s) Professor Margaret Semrud-Clikeman, Ph.D., Department of Educational Psychology, School Psychology Program, University of Texas at Austin. (512) 471-0274

Funding source: None

What is the purpose of this study? We are trying to learn the best ways to evaluate children suspected of having difficulties with social skill development as well as those who do not have such problems. More importantly, however, we are looking for better and more effective ways for parents and teachers to help students with social skill problems. We are asking parents of children who do not have these problems to participate in this study to determine how these children differ from children who do have social competence difficulties. We are also asking parents of children with such difficulties to participate in our study. Your child will be one of several hundred asked to participate in the project over several years.

What will be done if you take part in this research study? First, we will conduct a comprehensive assessment to determine whether your child has social skills difficulties or not. Your child will be asked to define words, solve problems, read and complete mathematics problems, complete block designs, write and draw, complete puzzles and answer questions about his/her feelings. Your child will also be asked to identify the emotions shown on computerized program. This assessment will take place in the School Psychology assessment rooms at the University of Texas or at your child's school. We will also ask you to have your child's teacher complete two rating scales that you will be provided. Parents will also be asked to complete an interview as well as behavioral rating scales and a developmental history.

What are the possible discomforts and risks? There are few known risks to this study. Your child may become fatigued from completing the tests. To avoid this difficulty, frequent breaks will be provided. Attendance in the intervention may bring up feelings that are uncomfortable. Additional support will be provided for your child and you will be fully informed about the techniques utilized as well as being provided with an outline of the activities. Treatment for serious psychological difficulties will not be provided but additional support can be found through the Austin Child Guidance Clinic at (512) 451-2242.

If you wish to discuss the information above or any other risks you may experience, you may ask questions now or call the Principal Investigator listed on the front page of this form.

What are the possible benefits to you or to others? You will receive a brief summary of the test results that may assist you in your child's school. However, this assessment is not meant to supplant comprehensive neuropsychological tests or take the place of school evaluations. Your child may benefit from the intervention but at this point in time the benefit is not established.

If you choose to take part in this study, will it cost you anything? No

Will you receive compensation for your participation in this study? No

What if you are injured because of the study? There are no known physical risks. No treatment will be provided for research related injury and no payment can be provided in the event of a medical problem.

If you do not want to take part in this study, what other options are available to you?

Participation in this study is entirely voluntary. You are free to refuse to be in the study, and your refusal will not influence current or future relationships with The University of Texas at Austin.

How can you withdraw from this research study and who should I call if I have questions?

If you wish to stop your participation in this research study for any reason, you should contact: Margaret Semrud-Clikeman, Ph.D. (512) 471-0274. You are free to withdraw your consent and stop participation in this research study at any time without penalty or loss of benefits for which you may be entitled. Throughout the study, the researchers will notify you of new information that may become available and that might affect your decision to remain in the study.

In addition, if you have questions about your rights as a research participant, **please contact Lisa Leiden, Ph.D., Chair, The University of Texas at Austin Institutional Review Board for the Protection of Human Subjects, 512/471-8871.**

How will your privacy and the confidentiality of your research records be protected?

Authorized persons from The University of Texas at Austin and the Institutional Review Board have the legal right to review your research records and will protect the confidentiality of those records to the extent permitted by law. If the research project is sponsored then the sponsor also

IRB APPROVED ON: 2/3/2006 ***EXPIRES ON 1/22/2007***

has the legal right to review your research records. Otherwise, your research records will not be released without your consent unless required by law or a court order.

If the results of this research are published or presented at scientific meetings, your identity will not be disclosed.

The audio recordings made during the interview phase of this study will be (a) coded so that no personally identifying information is visible on them; (b) will be kept in a secure place (e.g., a locked file cabinet in the investigator's office); (c) will be heard or viewed only for research purposes by the investigator and his or her associates; and (d) will be erased after they are transcribed or coded.

Will the researchers benefit from your participation in this *study*? No

Signatures:

As a representative of this study, I have explained the purpose, the procedures, the benefits, and the risks that are involved in this research study:

Signature and printed name of person obtaining consent **Date**

You have been informed about this study's purpose, procedures, possible benefits and risks, and you have received a copy of this Form. You have been given the opportunity to ask questions before you sign, and you have been told that you can ask other questions at any time. You voluntarily agree to participate in this study. By signing this form, you are not waiving any of your legal rights.

Printed Name of Subject **Date**

Signature of Subject **Date**

Signature of Principal Investigator **Date**

APPENDIX B: CONSENT FORM

IRB APPROVED ON: 2/3/2006 ***EXPIRES ON 1/22/2007***

CONSENT FORM

Assessment of Social Competence in Children with Developmental Disorders

Your child/adolescent is invited to participate in a study of children and adolescent's ability to understand social interactions. My name is Margaret Semrud-Clikeman, Ph.D. and I am a professor at The University of Texas at Austin, Department of Educational Psychology. I am asking for permission to include your child/adolescent in this study because we are studying children's ability to understand social relationships. We are working with children who have difficulty with understanding as well as those who do not . I expect to have **500 participants** in the study.

If you allow your child to participate, Margaret Semrud-Clikeman, Ph.D. will discuss the types of tasks your child and you will complete. These tasks include answering questions, completing block designs, drawing, and completing a computerized measure. In addition, your child and you will complete a behavioral rating scale. Completion of the tasks will take place at the Department of Educational Psychology at the University of Texas at Austin at your convenience **and at the convenience of the other children participating.** The assessment will be completed by doctoral students in school psychology under the supervision of Margaret Semrud-Clikeman, principal investigator.

Any information that is obtained in connection with this study and that can be identified with your child's name will remain confidential and will be disclosed only with your permission. His or her responses will not be linked to his or her name or your name in any written or verbal report of this research project. No information will be released without written permission from you.

Your decision to allow your child/adolescent to participate will not affect your or his or her present or future relationship with The University of Texas at Austin. If you have any questions about the study, please ask me. If you have any questions later, call me at (512) 471-0274. If you have any questions or concerns about your child/adolescent's participation in this study, call Professor Clarke Burnham, Chair of the University of Texas at Austin Institutional Review Board for the Protection of Human Research Participants at 232-4383.

You may keep the copy of this consent form.

You are making a decision about allowing your child/adolescent to participate in this study. Your signature below indicates that you have read the information provided above and have decided to allow him or her to participate in the study. If you later decide that you wish to withdraw your permission for your child/adolescent to participate in the study, simply tell me. You may discontinue his or her participation at any time.

____
Printed Name of your child

______________________________ ________________
Signature of Parent(s) or Legal Guardian Date

APPENDIX C: ASSENT FORM

IRB APPROVED ON: 2/3/2006 *EXPIRES ON 1/22/2007*

Signature of Investigator Date

C. <u>Assent form for child between the ages of 6 and 12.</u>

ASSENT FORM

Assessment of Social Competence in Children with Developmental Disorders

I agree to be in a study about how children understand emotions and friendships. This study was explained to my parents and they said that I could be in it. The only people who will know about what I say and do in the study will be the people in charge of the study and my parents.

In the study I will be asked questions about how I solve problems and answer questions. I will also work with block designs, draw, and work on a computer. I will also be asked how I feel about my myself and my friends. **If I am asked, I will be part of a group that meets to talk about how we know what we feel and gives me a chance to practice making friends.**

Writing my name on this page means that the page was read (by me/to me) and that I agree to be in the study. I know what will happen to me. If I decide to quit the study, all I have to do is tell the person in charge.

Child's Signature Date

B. <u>Assent form for child between 13 and 17 years of age</u>

"I have read the description of the study titled, Assessment of Social Competence in Children with Developmental Disorders, that is printed above, and I understand what the procedures are and what will happen to me in the study. I have received permission from my parent(s) to participate in the study, and I agree to participate in it. I know that I can quit the study at any time."

Signature of Minor Date

REFERENCE LIST

Abbott, R. D., & Berninger, V. W. (1993). Structural equation modeling of relationships among developmental skills and writing skills in primary and intermediate grade writers. *Journal of Educational Psychology, 85*, 478-508.

Ackerman, P. L., Beier, M. E., & Boyle, M. O. (2002). Individual differences in working memory within a nomological network of cognitive and perceptual speed abilities. *Journal of Experimental Psychology: General, 131*, 567-589.

Altemeier, L., Jones, J., Abbott, R. D., Berninger, V. W. (2006). Executive functions in becoming writing readers and reading writers: Note taking and report writing in third and fifth graders. *Developmental Neuropsychology, 29 (1*), 173, -186

Aylward, G. P., Verhulst, S. J., & Bell, S. (1990). Individual and combined effects of attention deficits and learning disabilities on computerized ADHD assessment. *Journal of Psychoeducational Assessment, 8*, 497-508.

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders (4th ed.).* Washington, DC: American Psychiatric Association.

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders: DSM-IV-TR (4th ed.).* Washington, DC: American Psychiatric Association.

August, G. J., & Garfinkel, B. D. (1990). Comorbidity of ADHD and reading disability among clinic-referred children. *Journal of Abnormal Psychology, 18*, 29-45.

Bachelder, B. L., & Denny, M. R. (1977). A theory of intelligence: II The role of span in a variety of intellectual tasks. *Intelligence, 1*, 237-256.

Baddeley, A. D. (1986). *Working Memory*. Oxford: Clarendon Press.

Baddeley, A. D. (1996). *The fractionation of working memory*. Paper presented at the Memory: Recording Experience in Cells and Circuits, Irving, CA.

Baddeley, A. D., & Hitch, G. (1974). Working memory. In G. A. Bower (Ed.), *Recent advances in learning and motivation* (Vol. 8, pp. 47-89). New York: Academic Press.

Baddeley, A. D., & Logie, R. H. (1999). Working memory: The multiple component model. In A. Miyake & P. Shah (Eds.), *Models of working memory: Mechanisms of active maintenance and executive control* (pp. 28-61). New York: Cambridge University Press.

Bain, A. (1991). Handwriting Disorders. In A. Bain, L. Bailet & L. Moats (Eds.), *Written language disorders: theory into practice* (pp. 23-42). Austin: Pro-Ed.

Barkley, R. A. (1990). *Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment*. New York: Guilford Press.

Barkley, R. A. (1994). *Attention deficit hyperactivity disorder: A handbook for diagnosis and treatment*. New York: Guilford Press.

Barkley, R. A. (1997a). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychology Bulletin, 121*(1), 65-94.

Barkley, R. A. (1997b). *ADHD and the nature of self-control*. New York: Guilford Press.

Barkley, R. A. (1998). Attention-deficit hyperactivity disorder. *A handbook for diagnosis and treatment. (2nd ed.)*. New York: Guilford Press.

Barkley, R. A. (2000). Genetics of childhood disorders: XVII. ADHD, Part 1: The executive functions and ADHD. *Journal of the American Academy of Child and Adolescent Psychiatry, 39*(8), 1064-1068.

Barkley, R. A. (2001). The inattentive type of ADHD as a distinct disorder: What remains to be done. *Clinical Psychology: Science and Practice, 8*, 489-493.

Barkley, R. A. (2003a). Attention-deficit/hyperactivity disorder. In E. J. Mash & R. A. Barkley (Eds.), *Child Psychopathology 2* (2nd ed., pp. 75-143). New York: Guilford Press.

Barkley, R. A. (2003b). Issues in the diagnosis of attention-deficit/hyperactivity disorder in children. *Brain and Development, 25*, 77-83.

Barkley, R. A., Anastopoulos, A. D., Guevremont, D. G., & Fletcher, K. F. (1991). Adolescents with attention deficit hyperactivity disorder: Patterns of behavioral adjustment, academic functioning, and treatment utilization. Journal of the *American Academy of Child and Adolescent Psychiatry, 30*, 752-761.

Barkley, R. A., Du Paul, G. J., & McMurray, M. B. (1990). Comprehensive evaluation of attention deficit disorder with and without hyperactivity as defined by research criteria. *Journal of Consulting and Clinical Psychology, 58*, 775-789.

Barkley, R. A., Fischer, M., Edelbrock, C. S., & Smallish, L. (1990). The adolescent outcome of hyperactive children diagnosed by research criteria: I. An 8-year prospective follow-up study. *Journal of the American Academy of Child and Adolescent Psychiatry, 29*, 546-557.

Barkley, R. A., & Grodzinsky, G. M. (1994). Are tests of frontal lobe functions useful in the diagnosis of attention deficit disorders? *The Clinical Neuropsychologist, 8,* 121-139.

Barkley, R. A., Grodzinsky, G. M., & Du Paul, G. J. (1992). Frontal lobe functions in attention deficit disorder with and without hyperactivity: A review and research report. *Journal of Abnormal Child Psychology, 20*, 163-188.

Bereiter, C. (1980). Development in writing. In L. W. Gregg & E. R. Steinberg (Eds.), *Cognitive processes in writing* (pp. 73-93). Hillsdale, NJ: Erlbaum.

Bereiter, C., Burtis, P.H., & Scardamalia, M. (1988). Cognitive operations in constructing main pointing written composition. *Journal of Memory & Language, 27*(3), 261-278.

Bereiter, C., & Scardmalia, M. (1987). *The psychology of written composition*. Hillsdale, New Jersey: Erlbaum.

Berninger, V. W. (1996). *Reading and writing acquisition: A developmental neuropsychological perspective*. New York: Westview Press.

Berninger, V. W. (1999). Coordinating transcription and text generation in working memory during composing: Automatic and constructive processes. *Learning Disability Quarterly, 22,* 99-112.

Berninger, V., Mizokawa, D., & Bragg, R. (1991). Theory-based diagnosis and remediation of writing disabilities. *Journal of School Psychology, 29*, 57-79.

Berninger, V. W., & Rutberg, J. (1992). Relationship of finger function to beginning writing: Application to diagnosis of writing disabilities. *Developmental Medicine and Child Neurology, 34,* 155-172.

Berninger, V. W., Abbott, R. D., Thomson, J., Wagner, R., Swanson, H, L., Wijsman, E. M., Raskind, W. (2006). Modeling phonological core deficits within a working memory architecture in children and adults with developmental dyslexia. *Scientific Studies of Reading*, 10(2), 165-198.

Berninger, V. W., Vaughan, K., Abbott, R. D., Abbott, S., Brooks, A., Rogan, L., Reed, E., & Graham, S. (1997). Treatment of handwriting fluency problems in beginning writing: Transfer from handwriting to composition. *Journal of Educational Psychology, 89*, 652-666.

Biederman, J., Faraone, S., Milberger, S., Guite, J., Mick, E., & Chen, L. (1996). A prospective 4-year follow-up study of attention-deficit hyperactivity and related disorders. *Archives of General Psychiatry, 53*, 437-446.

Biederman, J., Faraone, S. V., Keenan, K., Knee, E., & Tsuang, M. T. (1990). Family-genetic and psychosocial risk factors in DSM-III attention deficit disorder. *Journal of the American Academy of Child and Adolescent Psychiatry, 29*, 526-533.

Biederman, J., Faraone, S. V., Keenan, K., & Tsuang, M. T. (1991). Evidence of familial association between attention deficit disorder and major affective disorders. *Archives of General Psychiatry, 48*, 633-642.

Biederman, J., Keenan, K., & Faraone, S. V. (1990). Parent based diagnosis of attention deficit disorder predicts a diagnosis based on teacher report. *American Journal of Child and Adolescent Psychiatry, 29*, 698-701.

Biederman, J., Monuteaux, M. C., Doyle, A. E., Seidman, L. J., Wilens, T. E., Ferrero, F., et al. (2004). Impact of executive function deficits and attention-deficit/ hyperactivity disorder (ADHD) on academic outcomes in children. *Journal of Consulting and Clinical Psychology, 72*(October), 757-766.

Blakemore, S. J., Wolpert, D. M., & Frith, C. D. (1998). Central cancellation of self-produced tickle sensation. *Nature Neuroscience 1*(7):635-640

Casey, J. E., Rourke, B. P., & Del Dotto, J. E. (1996). Learning disabilities in children with attention deficit disorder with and without hyperactivity. *Child Neuropsychology, 2*, 83-98.

Casey, B. J., Trainor, R. J., Orendi, J. L., Schubert, A. B., Nystrom, L. E., Giedd, J. N., Castellanos, F. X., Haxby, J. V., Noll, D. C., Cohen, J. D., Forman, S. D., Dahl, & R. E., Rapoport, J. L. (1997). A developmental functional MRI study of prefrontal activation during performance of a Go-No-Go task. *Journal of Cognitive Neuroscience, 9*, 835-847.

Castellanos, F. X., Fine, E. J., Kaysen, D., Marsh, W. L., Rapoport, J. L., & Hallett, M. (1996). Sensorimotor gating in boys with Tourette's syndrome and ADHD: preliminary results. Biological Psychiatry, 39, 33-41.

Castellanos, F.X., & Tannock, R. (2002). Neuroscience of attention-deficit/hyperactivity disorder: the search for endophenotypes. *Nature Reviews Neuroscience, 3*(8):617-628.

Catts, H. W., & Kamhi, A. G. (1999). *Language and reading disabilities*. Boston, MA: Allyn and Bacon

Cohen, J. (1992). Quantitative methods in psychology, A power primer. *Psychological Bulletin. 112(1),* 155-159

Cohen, J. (1994). On the differential diagnosis of reading, attentional and depressive disorders. *Annals of Dyslexia, 44*, 165-184.

Colom, R., Flores-Mendoza, C., & Rebollo, I. (2003). Working memory and intelligence. *Personality and Individual Differences, 34*, 33-39.

Colom, R., Rebollo, I., Palacios, A., Juan-Espinosa, M., & Kyllonen, P. C. (2004). Working memory is (almost) perfectly predicted by g. *Intelligence, 32*, 277-296.

Conway, A. R. A., Cowan, N., Bunting, M., Therriault, D., & Minkoff, S. (2002). A latent variable analysis of working memory capacity, short-term memory capacity, processing speed, and general fluid intelligence. *Intelligence, 30*, 163-183.

Crystal., D. S., Ostrander, R., Chen, R. S., & August, G. J. (2001) Multimethod assessment of psychopathology among DSM-IV subtypes of children with attention-deficit/hyperactivity sisorder: self-, parent, and teacher reports. *Journal of Abnormal Child Psychology, 29(3)*, 189-205.

De La Paz, S., & Graham, S. (2002). Explicitly teaching strategies, skills, and knowledge: Writing instruction in middle school classrooms. *Journal of Educational Psychology, 94,* 687–698.

Daneman, M., & Carpenter, P.A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior*, 19, 450-466.

Daniels, C., Witt, K., Wolff, S., Jansen, O., & Deuschl, G. (2003). Rate dependency of the human cortical network subserving executive functions during generation of random number series—A functional magnetic resonance imaging study. *Neuroscience Letters, 345,* 25– 28.

Denckla, M. B. (1994). Measurement of executive function. In G. R. Lyon & N. A. Krasnegor (Eds.), *Attention, memory and executive function* (pp. 263-278). Baltimore: Brookes.

Deuel, R. K. (1992). Motor skill disorders. In S. R. Hooper, G. W. Hynd & R. E. Mattison (Eds.), *Developmental disorders: Diagnostic criteria and clinical assessment* (pp. 239-282). Hillsdale, NJ: Erlbaum.

Dixon, P., LeFevre, J. A., & Twilley, L. (1988). Word knowledge and working memory as predictors of reading skill. *Journal of Educational Psychology, 80*(4), 465-472.

Douglas VI. (1983) Attentional and cognitive problems. In: M. Rutter (Ed.), *Developmental neuropsychiatry* (pp. 280-329). New York: Guilford Press.

Duncan, J. (1995). Attention, intelligence, and the frontal lobes. In M. Gazzaniga (Ed.), *The cognitive neurosciences*. Cambridge, MA: MIT Press.

Duncan, J., Burgess, P., & Emslie, E. (1995). Fluid intelligence after frontal lobe lesions. *Neuropsychologia, 33,* 261-268.

Duncan, J., Emslie, H., Williams, P., Johnson, R., & Freer, C. (1996). Intelligence and the frontal lobe: The organization of goal-directed behavior. *Cognitive Psychology, 30,* 257-303.

Duncan, J., Seitz, R. J., Kolodny, J., Bor, S., Herzog, H., Ahmed, A., Newell, F. N., & Emslie, H. (2000). A neural basis for general intelligence. *Science, 289,* 457-460.

DuPaul, G. J., Power, T. J., Anastopoulos, A. D., & Reid, R. (1998). *AD/HD Rating Scale-IV: Checklists, norms, and clinical interpretation*. New York: Guilford.

Dykman, R. A., Ackerman, P. T., & Oglesby, D. M. (1979). Selective and sustained attention in hyperactive, learning disabled, and normal boys. *Journal of Nervous and Mental Diseases. 167,* 288-297

Ellis, A. W. (1983). Reading, writing, and dyslexia: *A cognitive analysis*. Hillsdale, NJ.: Erlbaum.

Engle, R. W., Tuholski, S. W., Laughlin, J. E., & Conway, A. R. A. (1999). Working memory, short-term memory, and general fluid intelligence: A latent-variable approach. *Journal of Experimental Psychology: General*, *128*(3), 309-331.

Eslinger, P. J., & Grattan, L. M. (1993). Frontal lobe and frontal striatal substrates for different forms of human cognitive flexibility. *Neuropsychologia, 31*, 17-28.

Evenden, J. L. (1999). Varieties of impulsivity. *Psychopharmacology, 146,* 348-346.

Faraone, S. V., Biederman, J., Mennin, D., & Russell, R. L. (1998). Bipolar and antisocial disorders among relatives of ADHD children: parsing familial subtypes of illness. *Neuropsychiatric Genetics, 81*, 108-116.

Fayol, M. (1999). From on-line management problems to strategies in written composition. In M. Torrance & G. Jeffery (Eds.), *The cognitive demands of writing* (pp. 13-23). Amsterdam: Amsterdam University Press.

Filipek, P. A., Semrud-Clikeman, M., Steingard, R. J., Kennedy, D. N., & Biederman, J. (1997). Volumetric MRI analysis comparing subjects having attention-deficit hyperactivity disorder with normal controls. *Neurology, 48*, 589-601.

Fischer, M., Barkley, R. A., Fletcher, K., & Smallish, L. (1993a). The adolescent outcome of hyperactive children diagnosed by research criteria: V. Predictors of outcome. *Journal of the American Academy of Child and Adolescent Psychiatry, 32*, 324-332.

Fischer, M., Barkley, R. A., Fletcher, K., & Smallish, L. (1993b). The stability of dimensions of behavior in ADHD and normal children over an 8 year period. *Journal of Abnormal Psychology, 21*, 315-337.

Flower, L. S., & Hayes, J. R. (1981). Plans that guide the composing process. In C. H. Frederksen & J. F. Dominic (Eds.), *Writing: The nature, development and teaching of written communication* (pp. 39-58). Hillsdale, NJ: Erlbaum.

Goel, V., & Dolan, R. J. (2003). Explaining modulation of reasoning by belief. *Cognition*, *87*: B11-22.

Graham, S. (1997). Executive control in the revising of students with learning and writing difficulties. *Journal of Educational Psychology, 89*, 223-234

Graham, S., Berninger, V., Abbott, R., Abbott, S., & Whitaker, D. (1997). The role of mechanics in composing of elementary school students: A new methodological approach. *Journal of Educational Psychology, 98,* 170-182.

Graham, S., & Harris, K. R. (1999). Assessment and intervention in overcoming writing difficulties: An illustration from the self-regulated strategy development model. *Language, Speech, and Hearing Services in Schools*, *30*, 255-264.

Harris, K. R., Graham., S,. & Mason, L. H. (2003). Self regulated strategy development in the classroom: Part of a balanced approach to writing instruction for students with disabilities. *Focus on Exceptional Children, 35*(7): 1-16.

Graham, S., Harris, K. R., MacArthur, C., & Schwartz, S. (1991). Writing and writing instruction for students with learning disabilities: Review of a research program. *Learning Disability Quarterly, 14,* 89-114.

Graham, S., & Weintraub, N. (1996). A review of handwriting research: Progress and prospects from 1980 to 1994. *Educational Psychology Review, 8*, 7-87.

Greenwald, E. A., Persky, H. R., Campbell, J. R., & Mazzeo, J. (1999). *NAEP 1998 writing report card for the nation and the states*. Washington DC: U.S. Department of Education, National Center for Statistics.

Gregg, N. (1991). Disorders of written expression. In A. Bain, L. L. Bailet & L. C. Moats (Eds.), *Written language disorders: Theory into practice* (pp. 65-97). Austin, TX: Pro-Ed.

Hart, E., Lahey, B., Loeber, R., Applegate, B., & Frick, P. (1995). Developmental change in attention-deficit/hyperactivity disorder in boys: A four-year longitudinal study. *Journal of Abnormal Child Psychology, 23,* 729-749.

Hayes, J. R. (1996). A new framework for understanding cognition and affect in writing. In C. M. Levy & S. Ransdell (Eds.), *The science of writing: theories, methods, individual differences, and applications* (pp. 1-28). Mahwah, New Jersey: Lawrence Erlbaum Associates.

Hayes, J. R., & Flower, L. S. (1980). Identifying the organization of writing processes. In L. W. Gregg & E. R. Steinberg (Eds.), *Cognitive processes in writing.* Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Hayes, J. R., & Flower, L. S. (1986). Writing research and the writer. *American Psychologist, 41*, 1106-1113.

Hayes, J. R., & Nash, J. G. (1996). On the nature of planning in writing. In C. M. Levy & S. Ransdell (Eds.), *The science of writing: theories, methods, individual differences, and applications* (pp. 29-58). Mahwah, New Jersey: Lawrence Erlbaum Associates.

Hinshaw, S. P. (1992). Externalizing behavior problems and academic underachievement in childhood and adolescence: Causal relationships and underlying mechanisms. *Psychological Bulletin, 111*, 127-155.

Hinshaw, S. P. (1994). *Attention deficits and hyperactivity in children.* Thousand Oaks, CA: Sage.

Hooper, S. R., Swartz, C. W., Montgomery, J. W., Reed, M. S., Brown, T. T., Wasileski, T. J., & Levine, M. D., (1993). Prevalence of writing problems across three middle school samples. *School Psychology Review, 22*, 610-620.

Hooper, S. R., Swartz, C. W., Wakely, M. B., de Kruif, R. E. L., & Montgomery, J. W. (2002). Executive functions in elementary school children with and without problems in written expression. *Journal of Learning Disabilities, 35*(1), 57-69.

Hooper, S., Temiyakarn, C., & Williams, M. D. (1993). The effects of cooperative learning and learner control on high- and average-ability students. *Educational Technology Research & Development, 41*(2), 5-18.

Horn, J. L., & Noll, J. (1997). Human cognitive capabilities: Gf-Gc Theory. In D. P. Flanagan, J. L. Genshaft & P. L. Harrison (Eds.), *Contemporary intellectual assessment: Theories, tests, and issues*. New York: The Guilford Press.

Hynd, G. W., Lorys, A. R., Semrud-Clikeman, M., Nieves, N., Huettner, M. I. S., & Lahey, B. B. (1991). Attention deficit disorder without hyperactivity: a distinct behavioral and neurocognitive syndrome. *Journal of Child Neurology, 6*(Supplement), S37-41.

Hynd, G. W., Semrud-Clikeman, M., Lorys, A. R., Novey, E. S., & Eliopulos, D. (1990). Brain morphology in developmental dyslexia and attention deficit disorder/hyperactivity. *Archives of Neurology, 47*, 919-926.

Johnson, D., & Myklebust, H. (1967). *Learning disabilities: Educational principles and practices.* New York: Grune and Stratton.

Kane, M. J., & Engle, R. W. (2000). Working memory capacity, proactive interference, and divided attention: Limits on long-term memory retrieval. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *26*, 333-358.

Kane, M. J., & Engle, R. W. (2002). The role of prefrontal cortex in working-memory capacity, executive attention, and general fluid intelligence: An individual differences perspective. *Psychonomic Bulletin & Review, 9*, 637-671.

Kane, M. J., & Engle, R. W. (2005). Working memory capacity and fluid intelligence are strongly related constructs: Comment on Ackerman, Beier, and Boyle. *Psychological Bulletin, 131(1)*, 66-71.

Kane, M. J., Hambrick, D. Z., & Conway, A. R. A. (2005). Working memory capacity and fluid intelligence are strongly related constructs: Comment on Ackerman, Beier, and Boyle (2005). *Psychological Bulletin, 131*(1), 66-71.

Kane, M. J., Hambrick, D. Z., Tuholski, S. W., Wilhelm, O., Payne, T. W., & Engle, R. W. (2004). The generality of working memory capacity: A latent-variable approach to verbal and visuospatial memory span and reasoning. *Journal of Experimental Psychology: General, 133*, 189-217.

Kaufman, J., Birmaher, B., Brent, D., Rao, U., Flynn, C., Moreci, P., Williamson, D., & Ryan, N. (1997). Schedule for affective disorders and schizophrenia for school-age children-present and lifetime version (K-SADS-PL): initial reliability and validity data. *Journal of the American Academy of Child and Adolescent Psychiatry.* 36, 980–988.

Kellogg, R. T. (1996). A model of working memory in writing. In C. M. Levy & S. Ransdell (Eds.), *The science of writing: Theories, methods, individual differences, and applications* (pp. 57-71). Mahwah, NJ: Erlbaum.

Kellogg, R. T. (1999). Components of working memory in text production. In M. Torrance & G. Jeffery (Eds.), *The cognitive demands of writing* (pp. 143-161). Amsterdam: Amsterdam University Press.

Kellogg, R. T. (2001). Competition for working memory among writing processes. *American Journal of Psychology, 114(2),* 175-191.

Koechlin, E., Basso, G., Pietrini, P., Panzer, S., & Grafman, J. (1999). The role of the anterior prefrontal cortex in human cognition. *Nature, 399*, 148-151.

Kyllonen, P., & Christal, R. (1990). Reasoning ability is (little more than) working memory capacity?! *Intelligence, 14*, 389-433.

Lahey, B. B., Applegate, B., McBurnett, K., Biederman, J., Greenhill, L., Hynd, G. W., Barkley, R. A., Newcorn, J., Jensen, P., Richters, J., Garfinkel, B., Kerdyk, J., Frick, P. J., Ollendick, T., Perez, D., Hart, E. L., Waldman, I., & Shaffer, D. (1994). DSM-IV field trials for attention-deficit/hyperactivity disorder in children and adolescents. *American Journal of Psychiatry, 152*, 1673-1685.

Lambert, N. M., & Sandoval, J. (1980). The prevalence of learning disabilities in a sample of children considered hyperactive. *Journal of Abnormal Psychology, 8*, 33-50.

Lea, J., & Levy, C. M. (1999). Working memory as a resource in the writing process. In M. Torrance & G. Jeffery (Eds.), *The cognitive demands of writing* (pp. 63-82). Amsterdam: Amsterdam University Press.

Levine, M. D., Hooper, S. R., Montgomery, J. W., Reed, M. S., Sandier, A., Swartz, C., & Watson, T. (1993). Learning disabilities. An interactive developmental paradigm. In G. R. Lyon, D. B. Gray, J. E. Kavanagh & N. A. Krasnegor (Eds.), *Better understanding learning disabilities. New views from research and their implications for educational and public policies* (pp. 229-250). Baltimore: Brookes.

Levy, F., & Hay, D. (2001). *Attention, Genes and ADHD.* East Sussex.: Brunner-Rutledge.

Levy, F., Hay, D. A., McStephen, M., Wood, C., & Waldman, I. (1997). Attention-deficit hyperactivity disorder: A category or a continuum? Genetic analysis of a large-scale twin study. *Journal of the American Academy of Child and Adolescent Psychiatry, 36*, 737-744.

Lezak, M. D. (1995). *Neuropsychological assessment*. New York: Oxford University Press.

Luria, A. R. (1980). *Higher cortical functions in man*. New York: Basic Books.

Marcie, P., & Hecaen, H. (1979). Agraphia: Writing disorders associated with unilateral cortical lesions. In K. M. Heilman & E. Valenstein (Eds.), *Clinical Neuropsychology* (pp. 92-127). New York: Oxford University Press.

Marshall, R. M., Hynd, G. W., Handwerk, M. J., & Hall, J. (1997). Academic underachievement in ADHD subtypes. *Journal of Learning Disabilities, 30* (6), 635-642.

Mayes, S. D., Calhoun, S. L., & Crowell, E. W. (2000). Learning disabilities and ADHD: Overlapping spectrum disorders. *Journal of Learning Disabilities, 33*(5), 417-.

McBurnett, K., Pfiffner, L. J., & Frick, P. J. (2001). Symptom properties as a function of ADHD type: An argument for continued study of sluggish cognitive tempo. *Journal of Abnormal Child Psychology, 29*, 207-213.

McCutchen, D. (1996). A capacity theory of writing: Working memory in composition. *Educational Psychology Review, 8*, 299-325.

McCutchen, D. (2000). Knowledge, processing, and working memory: Implications for a theory of writing. *Educational Psychologist, 35(1)*, pp. 13-23.

Milich, R., Balentine, A. C., & Lynam, D. R. (2001). ADHD combined type and inattentive type are distinct and unrelated disorders. *Clinical Psychology: Science and Practice, 8,* 463-488.

Mirsky, A. F. (1996). Disorders of attention: A neuropsychological perspective. In G. R. Lyon & N. A. Krasnegor (Eds.), *Attention, memory, and executive function* (pp. 71-96). Baltimore, Maryland: Paul H. Brooks Publishing Company.

Morgan, A. E., Hynd, G. W., Riccio, C. A., & Hall, J. (1996). Validity of DSM-IV ADHD predominantly inattentive and combined types: Relationship to previous DSM diagnoses/subtype differences. *Journal of the American Academy of Child and Adolescent Psychiatry, 35*(3), 325-333.

Muenz, T. A., Ouchi, B. Y., & Cole, J. C. (1999). Item analysis of written expression scoring systems from the PIAT-R and WIAT. *Psychology in the Schools, 36 (1),* pp. 21-40.

Murphy, K. R., Barkley, R. A., & Bush, T. (2001). Executive functioning and olfactory identification in young adults with attention deficit hyperactivity disorder (ADHD). *Neuropsychology, 15*, 211-220.

Nicolson, R. I., & Fawcett, A. J. (1999). Developmental dyslexia: The role of the cerebellum. *Dyslexia: An International Journal of Research and Practice, 15,* 155-177.

Norman, D. A., & Shallice, T. (1986). Attention to action: Willed and automatic control of behavior. In R. J. Davidson, G. E. Schwartz & D. Shapiro (Eds.), *Consciousness and self-regulation* (Vol. 4, pp. 1-18). New York: Plenum Press.

Oosterlaan, J., Scheres, A., & Sergeant, J. A. (2005). Which executive functioning deficits are associated with AD/HD, ODD/CD and comorbid AD/HD+OCD/CD? *Journal of Abnormal Child Psychology, 33*(1), 69-86.

Owen, A. M. (1997). The functional organization of working memory processes within human lateral frontal cortex: The contribution of functional neuroimaging. *Neuroscience, 9,* 1329-1339.

Pennington, B. F., & Ozonoff, S. (1996). Executive functions and developmental psychopathology. *Journal of Child Psychology and Psychiatry, 37,* 51-87.

Prabhakharan, V., Smith, J. A. L., Desmond, J. E., Glover, G. H., & Gabrieli, D. E. (1997). Neural substrates of fluid reasoning: an fMRI study of neocortical activation during performance of the Raven's Progressive Matrices Test. *Cognitive Psychology, 33*, 43-63.

Psychological Corporation, (1992). *Wechsler Individual Achievement Test, (WIAT)*. San Antonio, Tx: Psychological Corporation.

Puig-Antich, J., & Chambers, W. (1978). *The Schedule for Affective Disorders and Schizophrenia for School-Age Children (Kiddie-SADS)*. New York: New York State Psychiatric Institute.

Puig-Antich, J., & Ryan, N. (1986). *The Schedule for Affective Disorders and Schizophrenia for School-age children I (Kiddie-SADS) - 1986.* Pittsburgh: Western Psychiatric Institute and Clinic.

Quay, H. C. (1997). Inhibition and attention deficit hyperactivity disorder. Journal of *Abnormal Psychology, 25*, 7-13.

Rapport, M. D., Scanlan, S. W., & Denney, C. B. (1999). Attention-deficit/hyperactivity disorder and scholastic achievement: A model of dual developmental pathways. *Journal of Child Psychology and Psychiatry, 40,* 1169-1183.

Reynolds, C. R., & Kamphaus, R. W. (2002). *A clinician's guide to the Behavior Assessment System for Children (BASC).* New York: Guilford Publications.

Roth, F. P. (2000). Narrative writing: Development and teaching with children with writing difficulties. *Topics in Language Disorders, 20(4),* 15–28.

Rubia, K., (2002). The dynamic approach to neurodevelopmental psychiatric disorders: use of fMRI combined with neuropsychology to elucidate the dynamics of psychiatric disorders, exemplified in ADHD and schizophrenia. *Behavioral Brain Research, 130*,47-50.

Rubia, K., Overmeyer, S. O., Taylor, E., Brammer, M., Williams, S. C., Simmons, A., & Bullmore, E. T. (1999). Hypofrontality in attention deficit hyperactivity disorder during higher order motor control: A study with fMRI. *American Journal of Psychology, 156*(6), 891-896.

Scardamalia, M., & Bereiter, C. (1986). Written composition. In M. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed., pp. 778–803). New York: Macmillan.

Scardamalia, M., Bereiter, C., & Goleman, H. (1984). The role of production factors in writing ability. In M. Nystrand (Ed.)*, What writers know: The language, process, and structure of written discourse* (pp. 173-210). New York: Academic Press.

Scardamalia, M., Bereiter, C., & Steinbach, R. (1984). Teachability of reflective processes in written composition. *Cognitive science: A multidisciplinary journal*. 8(2), 173-190.

Schachar, R. J., Tannock, R., & Logan, G. D. (1993). Inhibitory control, impulsiveness, and attention deficit hyperactivity disorder. *Clinical Psychology Review, 13*(721-740).

Schneck, C. (1991). Comparison of pencil-grip patterns in first graders with good and poor writing skills. *American Journal of Occupational Therapy, 45,* 701-706.

Schoenbaum, G., Chiba, A. A., & Gallagher, M. (1998). Orbitofrontal cortex and basolateral amygdale encode expected outcomes during learning. *Nature Neuroscience, 1*, 155-159.

Seidman, L. J., Biederman, J., Faraone, S. V., Weber, W., & Ouellette, C. (1997). Toward defining a neuropsychology of attention-deficit/hyperactivity disorder: Performance of children and adolescents from a large clinically referred sample. *Journal of Consulting and Clinical Psychology, 65,* 150-160.

Seidman, L. J., Biederman, J., Monuteaux, M. C., Weber, W., & Faraone, S. V. (2000). Neuropsychological functioning in nonreferred siblings of children with attention-deficit/hyperactivity disorder. *Journal of Abnormal Psychology, 109,* 252-265.

Semrud-Clikeman, M., Biederman, J., Sprich-Buckminster, S., Lehman, B. K., Faraone, S. V., & Norman, D. (1992). Comorbidity between ADHD and learning disability: A review and report in a clinically referred sample. *Journal of the American Academy of Child and Adolescent Psychiatry, 31*, 439-448.

Sergeant, J. A., Oosterlaan, J., & Van der Meere, J. J. (1999). Information processing and energetic factors in attention-deficit hyperactivity disorder. In H. Quay (Ed.), *Handbook of disruptive behavior disorders* (pp. 75-104). New York: Kluwer Academic.

Sergeant, J. A., & Van der Meere, J. J. (1990). Additive factor method applied to psychopathology with special reference to childhood hyperactivity. *Acta Psychologica, 74*, 277-295.

Sergeant, J. A., & van der Meere, J. J. (1994). Toward an empirical child psychopathology. In D. K. Routh (Ed.), *Disruptive behavior disorders in childhood* (pp. 59-85). New York: Plenum Press.

Silliman, E. R., & Wilkinson, L. C. (1994). Observing is more than looking. In G. P. Wallach & K. G. Butler (Eds.), *Language learning disabilities in school-age children and adolescents: Some principles and applications*. Boston: Allyn & Bacon.

Singer, B. D., & Bashir, A. S. (1999). What are executive functions and self-regulation and what do they have to do with language-learning disorders? *Language, Speech, and Hearing Services in Schools, 30*, 265-273.

Sonuga-Barke, E. J. S., Houlberg, K., & Hall, M. (1994). When is impulsiveness not impulsive: the case of hyperactive children's cognitive style? *Journal of Child Psychology and Psychiatry, 35*, 1247-1253.

Sonuga-Barke, E. J. S., Taylor, E., & Heptinstall, E. (1992). Hyperactivity and delay aversion-II. The effect of self versus externally imposed stimulus presentation periods on memory. *Journal of Child Psychology and Psychiatry, 33*(2), 399-409.

Stankov, L. (2000). Complexity, metacognition, and fluid intelligence. *Intelligence, 28*, 121-143.

Sut, H. M., Oberauer, K., Wittmann, W. W., Wilhelm, O., & Schulze, R. (2002). Working-memory capacity explains reasoning ability - and a little bit more. *Intelligence*, *30*, 261-288.

Swanson, H. L. (1983). A developmental study of vigilance in learning-disabled and nondisabled children. *Journal of Abnormal Child Psychology, 11*, 415-429.

Swanson, H. L., & Berninger, V. (1994). Individual differences in children's working memory and writing skill. *Journal of Experimental Child Psychology, 63*, 358-385.

Swanson, J., Posner, M., Cantwell, D., Wigal, S., Crinella, F., Filipek, P. A., Emerson, J., Tucker, D., & Nalcioglu, O. (1998). Attention deficit/hyperactivity disorder: Symptom domains, cognitive processes, and neural networks. In R. Parasuraman (Ed.), *The attentive brain*. (pp. 445-460). Cambridge, MA: MIT Press.

Swartz, C. W., Hooper, S. R., Montgomery, J. W., Wakely, M. B., de Kruif, R. E. L., Reed, M., Brown, T. T., Levine, M. D., & White, K. E (1999). Using generalizability theory to estimate the reliability of writing scores derived from holistic and analytical scoring methods. *Educational and Psychological Measurement, 59*, 492-506.

Tannock, R. (2000). Attention-deficit/hyperactivity disorder with anxiety disorders. In T. E. Brown (Ed.). *Attention deficit disorders and comorbidities in children, adolescents, and adults* (pp.125-170). Washington D.C.: American Psychiatric Press.

Tarnowski, K. J., Prinz, R. J., & Nay, S. M. (1986). Comparative analysis of attentional deficits in hyperactive and learning-disabled children. *Journal of Abnormal Child Psychology, 95*, 341-345.

Taylor, E. (1998). Clinical foundations of hyperactivity research. *Behavior Brain Research, 94*(1), 11-24.

Tranel, D., Anderson, S. W., & Benton, A. (1994). Development of the concept of "executive function" and its relationship to the frontal lobes. In F. Boller & J. Grafman (Eds.), *Handbook of Neuropsychology* (Vol. 9, pp. 125-148). New York: Elsevier.

Treiman, R. (1998). Why spelling? The benefits of incorporating spelling into beginning reading instruction. In J. L. Metsala & L. C. Ehri (Eds.), *Word recognition in beginning literacy* (pp. 289-313). Mahwah, NJ: Erlbaum.

Turner, M. L., & Engle, R. W. (1989). Is working memory capacity task dependent? *Journal of Memory and Language, 28*, 127-154

Unsworth, N., & Engle, R. W. (2005). Individual differences in working memory capacity and learning: Evidence from the serial reaction time task. *Memory & Cognition, 33* (2), 213-220

Vaughn, M. L., Riccio, C. A., Hynd, G. W., & Hall, J. (1997). Diagnosing ADHD (Predominantly inattentive and combined type subtypes): Discriminant validity of the Behavior Assessment System for Children and the Achenbach Parent and Teacher Rating Scales. *Journal of Clinical Child Psychology, 26*, 349-357.

Weaver, C. (1998). Teaching grammar in the context of writing. In C. Weaver (Ed.), *Lessons to share: On teaching grammar in context* (pp. 18-38). Portsmouth, NH: Heinemann.

Wechsler, D. (1992). *Wechsler Individual Achievement Test* (2nd Edition). New York: Psychological Corporation

Wechsler, D. (1999). *Wechsler Abbreviated Scale of Intelligence (WASI*). San Antonio, Tx: Psychological Corporation.

Wechsler, D. (2003). *Wechsler Intelligence Scale for Children (4th ed*.). San Antonio, TX: The Psychological Corporation.

Welsh, M. C., & Pennington, B. F. (1989). Assessing frontal lobe functioning in children: Views from developmental psychology. *Developmental Neuropsychology, 4,* 199-230.

Wood, J.N., Romero, S.G., Makale, M., & Grafman, J. (2003). Category-specific representations of social and non-social knowledge in the human prefrontal cortex. *Journal of Cognitive Neuroscience 15,* 236-248.

Zametkin, A. J., Nordahl, T. E., Gross, M., King, A. C., Semple, W. E., Rumsey, J., Hamburger, S., & Cohen, R. M. (1990). Cerebral glucose metabolism in adults with hyperactivity of childhood onset. *New England Journal of Medicine, 323*:1361-1366.

Zentall, S. S., Moon, S. M., Hall, A. M., & Grskovic, J. A. (2001). Learning and motivational characteristics of boys with AD/HD and/or giftedness. *Exceptional Children, 67*: 499-519.

Zentall, S. S. , & Smith, Y. N. (1993). Mathematical performance and behavior of children with hyperactivity, with and without coexisting aggression. *Behavior Research and Therapy, 31*, 701-710.

VITA

Reshma Babra Naidoo was born in Pietermaritzburg, South Africa on the May 11th 1962, the daughter of Sardool Singh Ramsingh and Vidya Ramsingh. After completing her work at Clare Hills High School, Durban, South Africa, she entered the University of Durban in Westville, South Africa. She received the degrees of Bachelor of Pedagogics in 1984, and Honors, Bachelor of Arts, in 1986. During the following years she was employed as an English and Physical Education teacher by the Department of Education in Natal, South Africa, and lecturer of Physical Education at the Giyani College of Education, South Africa. She entered the Graduate School at The University of Texas at Austin in January 1991, where she completed the Masters of Education in Kinesiology. She entered the Graduate School at Michigan State University in 1995, where she completed the Doctor of Philosophy. In September 2001 she entered the Graduate School at the University of Texas at Austin.

Permanent Address: 2600 Rollingwood Drive, Austin, Texas 78746

This dissertation was typed by the author.